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(12) United States Patent

Uchida et al.

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(54) OPTICAL SYSTEM AND OPTICAL INSTRUMENT, IMAGE PICKUP APPARATUS, AND IMAGE PICKUP SYSTEM USING THE SAME

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(72) Inventors: **Yoshihiro Uchida**, Tokyo (JP); **Kenichiro Abe**, Tokyo (JP); **Keisuke Ichikawa**, Tokyo (JP)

(73) Assignee: **OLYMPUS CORPORATION**, Tokyo

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 14/529,885

(22) Filed: Oct. 31, 2014

(65) **Prior Publication Data**

US 2015/0103413 A1 Apr. 16, 2015

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2013/075153, filed on Sep. 18, 2013.

(30) Foreign Application Priority Data

Sep. 21, 2012 (JP) 2012-208980

(51) **Int. Cl. G02B 15/14** (2006.01) **G02B 13/18** (2006.01)
(Continued)

(58) Field of Classification Search CPC G02B 21/025; G02B 13/18; G02B 13/24;

See application file for complete search history.

(56) References Cited

U.S. PATENT DOCUMENTS

7,646,542 B2 1/2010 Yonetani 7,663,807 B2 2/2010 Yonetani (Continued)

FOREIGN PATENT DOCUMENTS

JP 11-133312 5/1999 JP 2008-185965 8/2008

(Continued)

OTHER PUBLICATIONS

International Search Report, dated Jan. 7, 2014, issued in corresponding International Application No. PCT/JP2013/075153.

(Continued)

Primary Examiner — Mahidere Sahle (74) Attorney, Agent, or Firm — Kenyon & Kenyon LLP

(57) ABSTRACT

An optical system which forms an optical image on an image pickup element, comprising in order from an object side,

- a first lens unit having a positive refractive power, which includes a plurality of lenses,
- a stop, and
- a second lens unit which includes a plurality of lenses, wherein
- the first lens unit includes a first object-side lens which is disposed nearest to an object, and
- the second lens unit includes a second image-side lens which is disposed nearest to an image, and
- the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

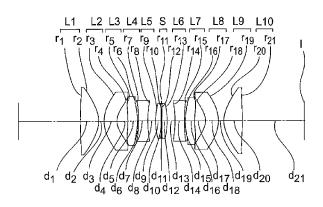
the following conditional expressions are satisfied:

 $\beta \le -1.1$ (15) 0.08 \ NA (16)

 $1.0 < WD/BF \tag{19}$

 $0.5 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj})/\phi_s \le 4.0$ (20).

10 Claims, 107 Drawing Sheets



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(51)	Int. Cl. (2006.01)			FOREIGN PATENT DOCUMENTS		
	G02B 13/26 G02B 21/02	(2006.01) (2006.01)	JP JP	2008-309901 2009-205063 2009-251081	12/2008 9/2009 10/2009	
(56)		References Cited	ĴЪ	2012-173491 OTHER PU	9/2012 UBLICATIONS	

7,965,450 B2 6/2011 Yonetani 8,564,756 B2 10/2013 Kuba

U.S. PATENT DOCUMENTS

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FIG. 1

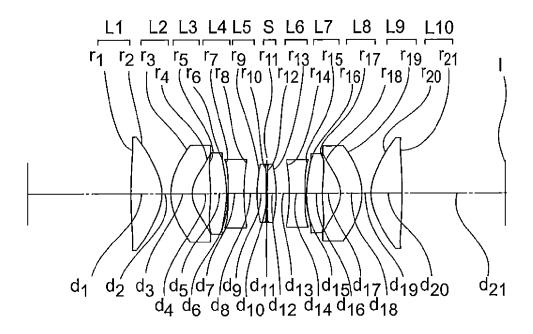


FIG. 2A

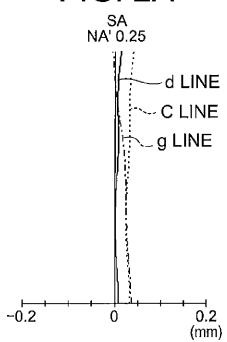


FIG. 2B

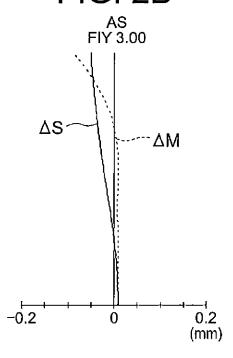


FIG. 2C

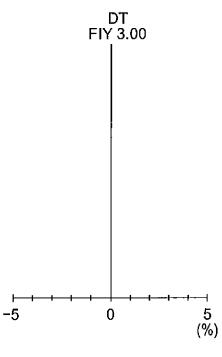


FIG. 2D

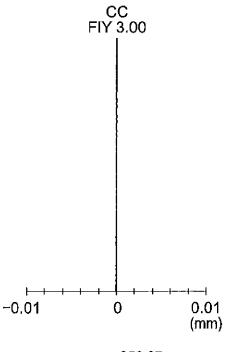
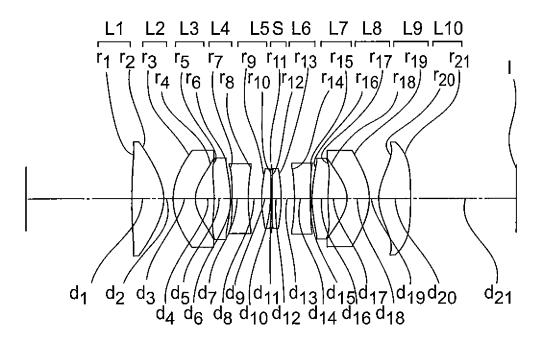


FIG. 3



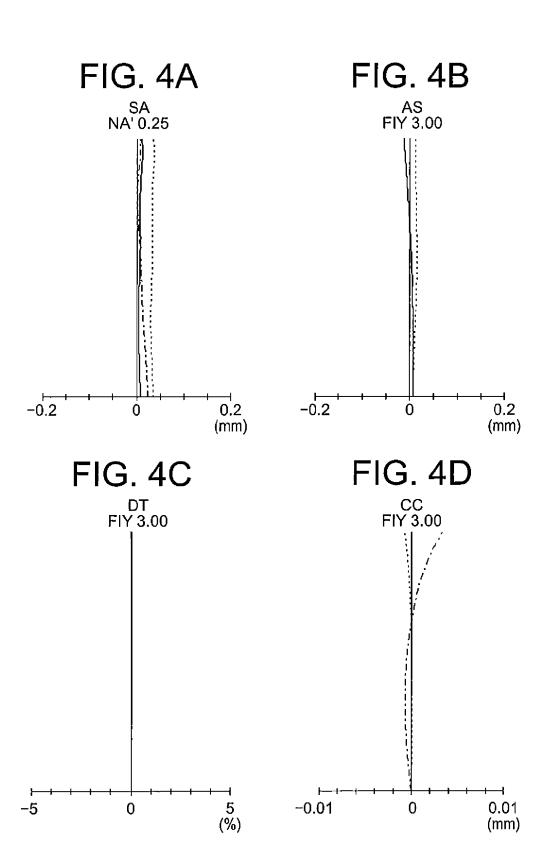
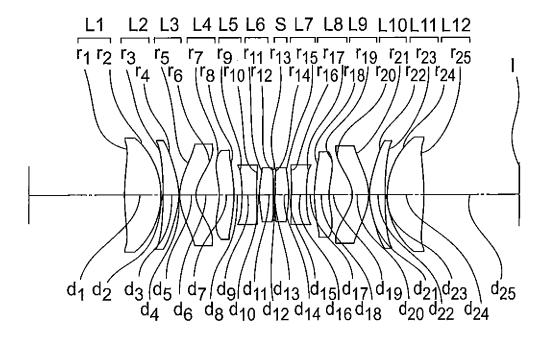


FIG. 5



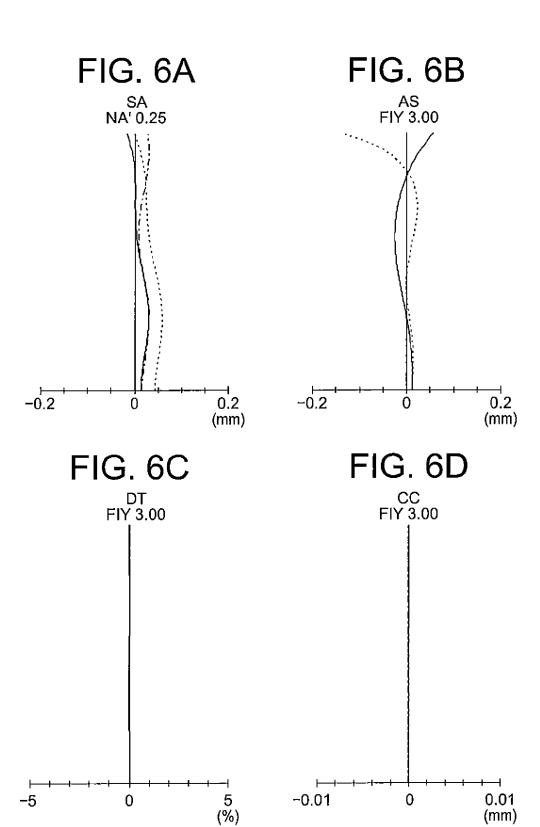
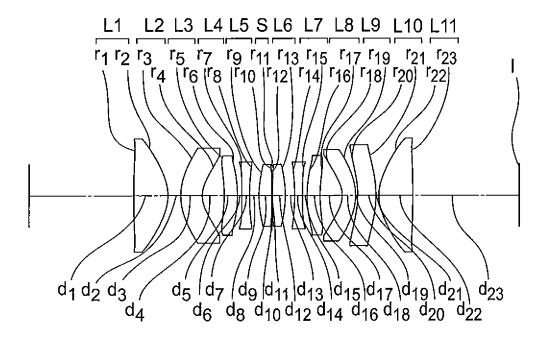


FIG. 7



0.01 (mm)

0

Ó

-5

5 (%)

-0.01

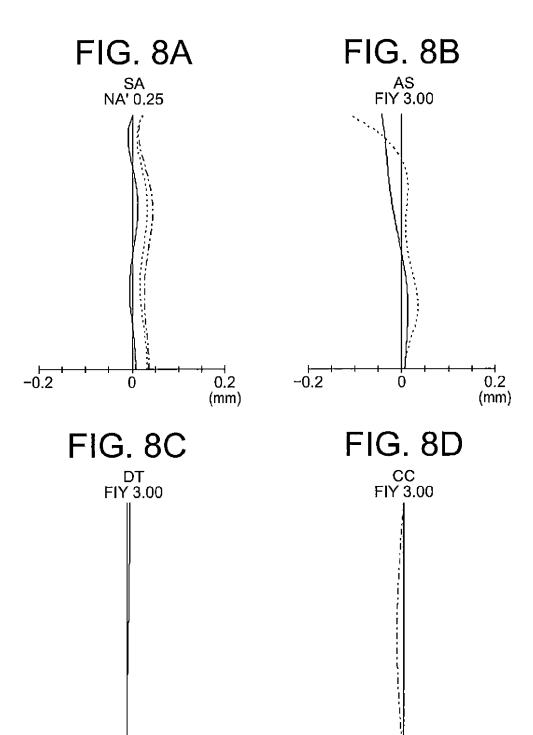


FIG. 9

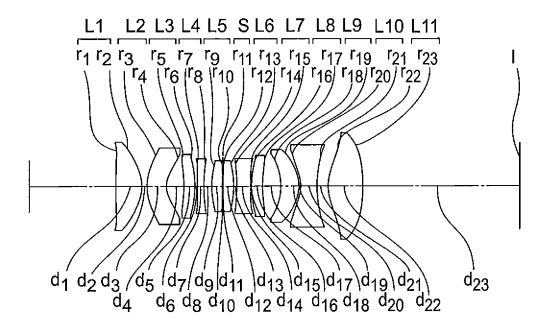


FIG. 10A

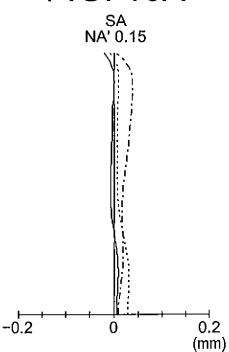


FIG. 10B

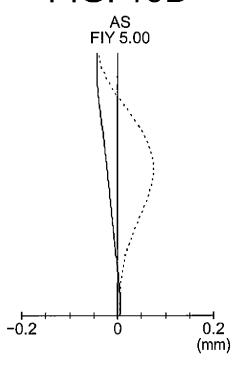


FIG. 10C

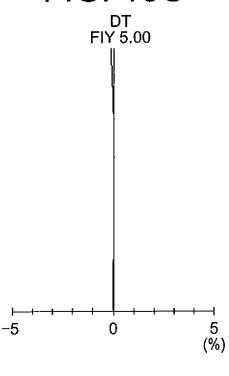


FIG. 10D

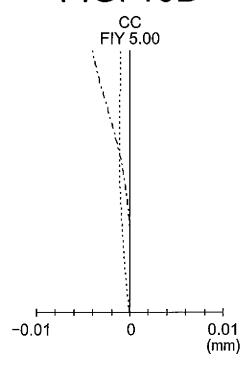


FIG. 11

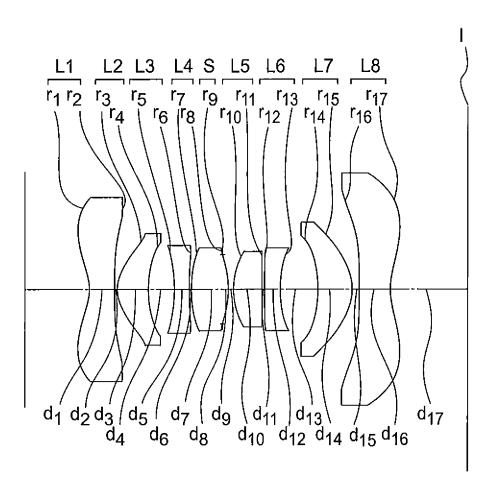


FIG. 12A

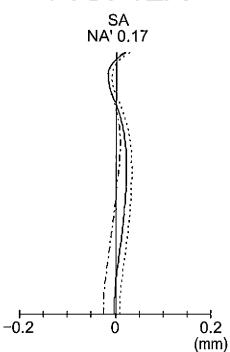


FIG. 12B

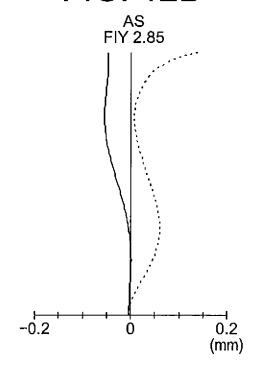


FIG. 12C

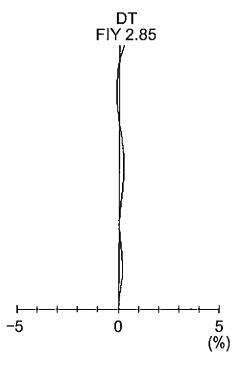


FIG. 12D

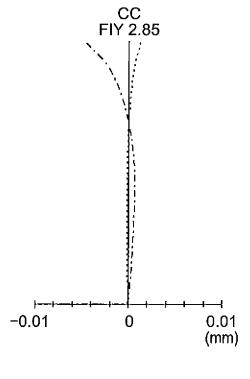
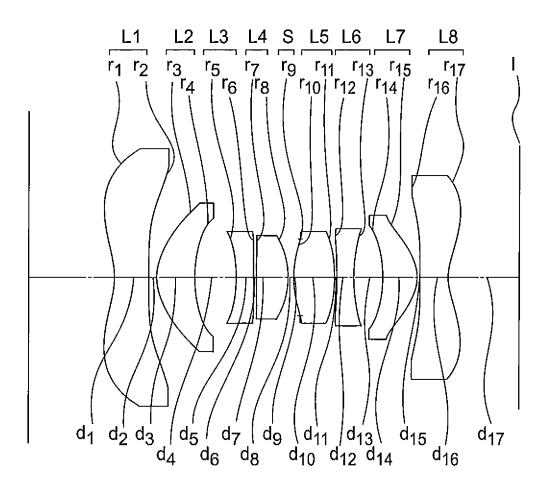
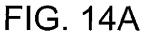


FIG. 13





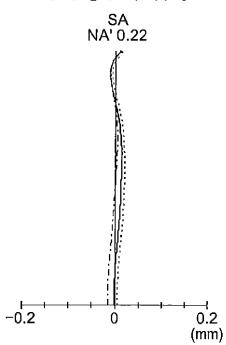


FIG. 14B

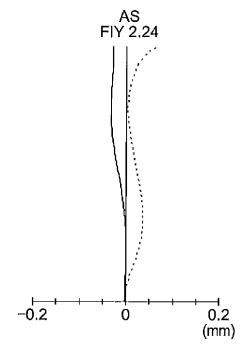


FIG. 14C

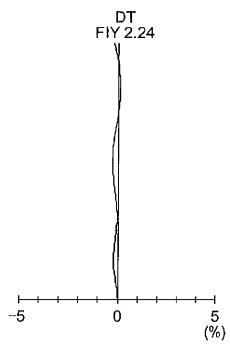


FIG. 14D

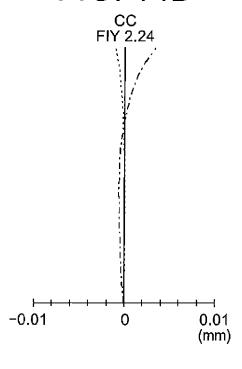


FIG. 15A

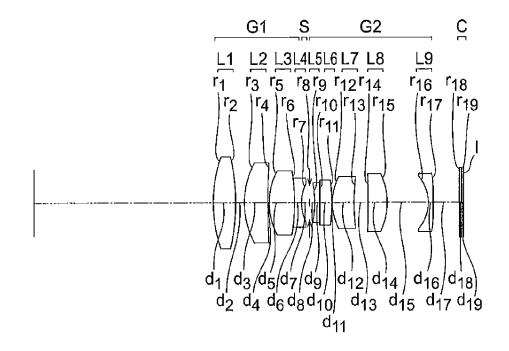


FIG.15B FIG.15C FIG.15D FIG.15E

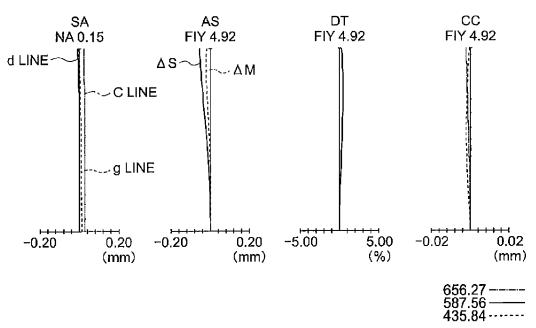


FIG. 16A

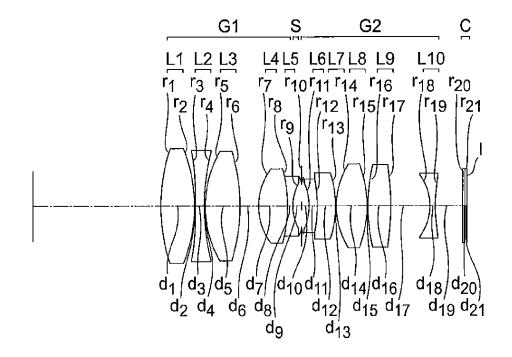


FIG.16B FIG.16C FIG.16D FIG.16E

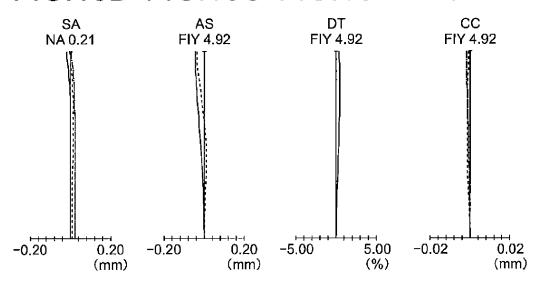


FIG. 17A

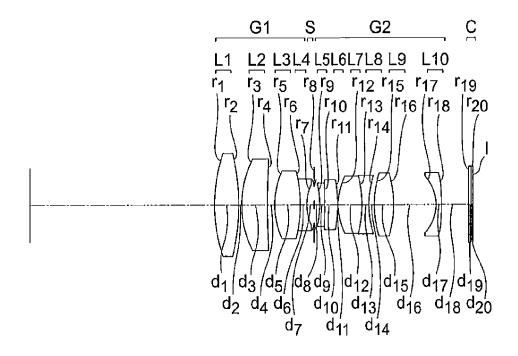


FIG.17B FIG.17C FIG.17D FIG.17E

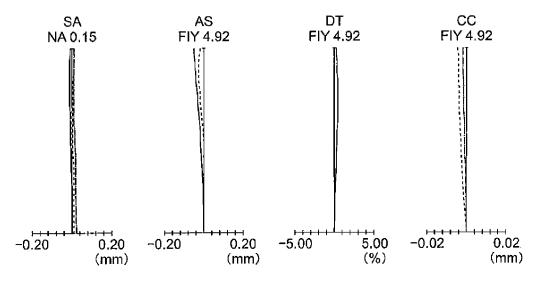


FIG. 18A

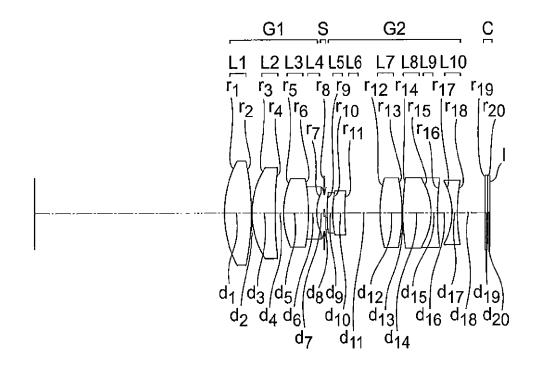


FIG.18B FIG.18C FIG.18D FIG.18E

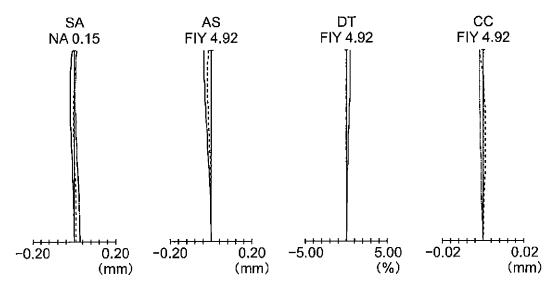


FIG. 19A

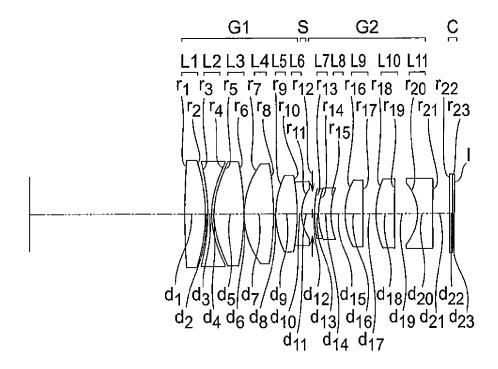


FIG.19B FIG.19C FIG.19D FIG.19E

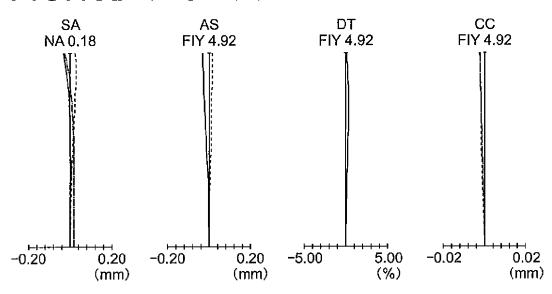


FIG. 20A

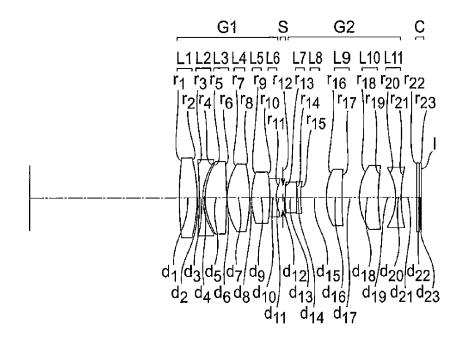


FIG.20B FIG.20C FIG.20D FIG.20E

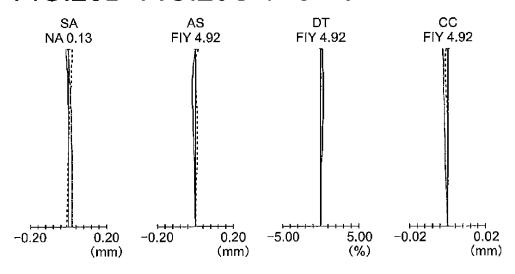


FIG. 21A

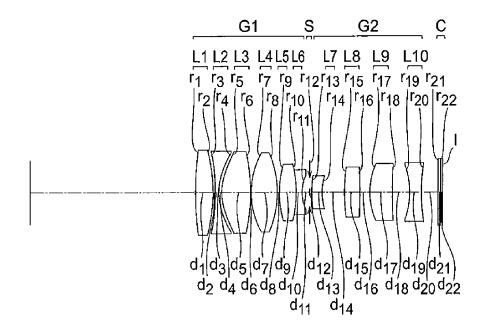


FIG.21B FIG.21C FIG.21D FIG.21E

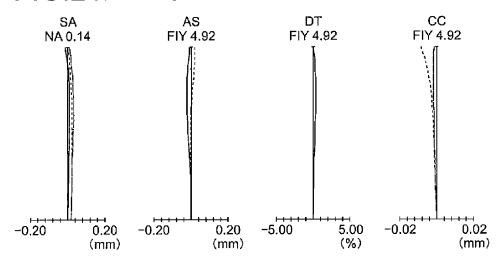


FIG. 22A

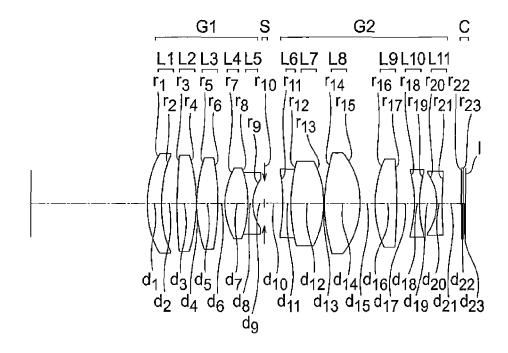


FIG.22B FIG.22C FIG.22D FIG.22E

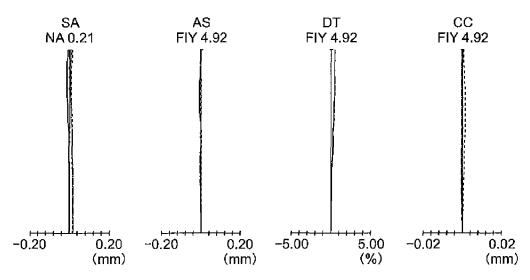


FIG. 23A

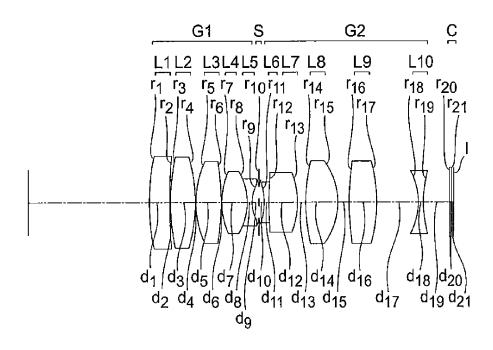


FIG.23B FIG.23C FIG.23D FIG.23E

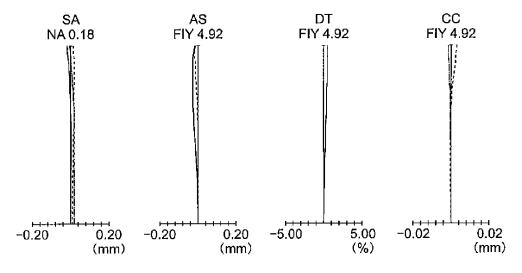


FIG. 24A

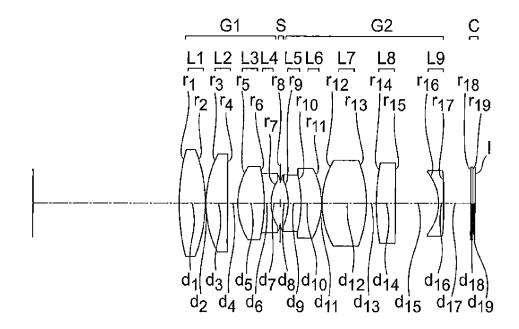


FIG.24B FIG.24C FIG.24D FIG.24E

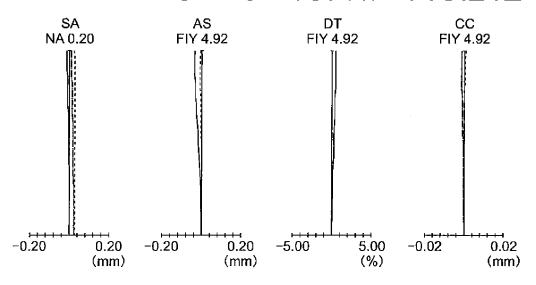


FIG. 25A

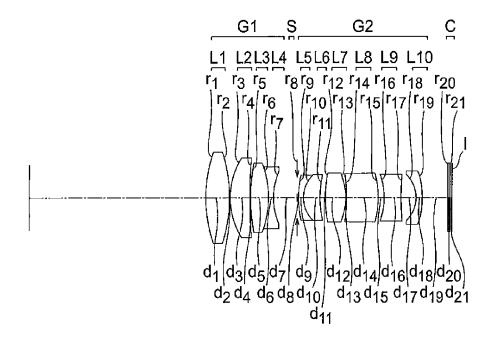


FIG.25B FIG.25C FIG.25D FIG.25E

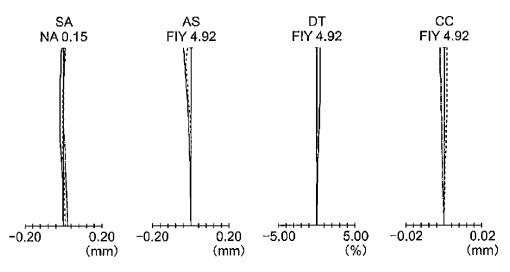


FIG. 26A

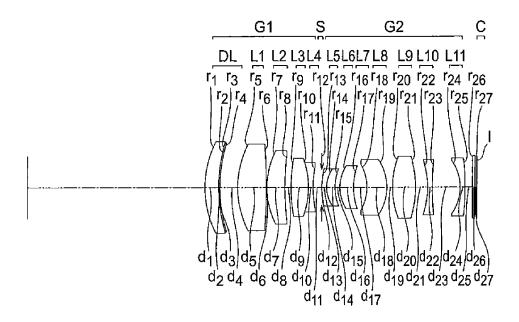


FIG.26B FIG.26C FIG.26D FIG.26E

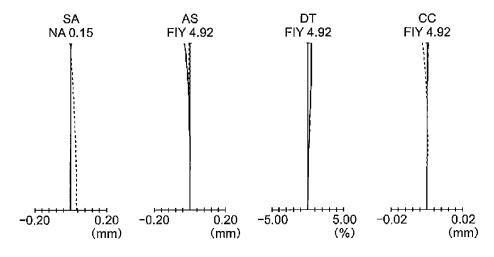


FIG. 27A

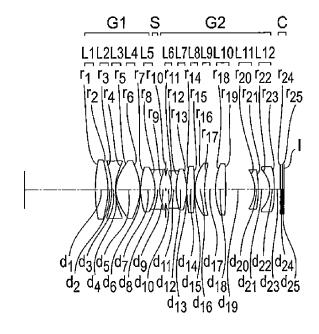


FIG.27B FIG.27C FIG.27D FIG.27E

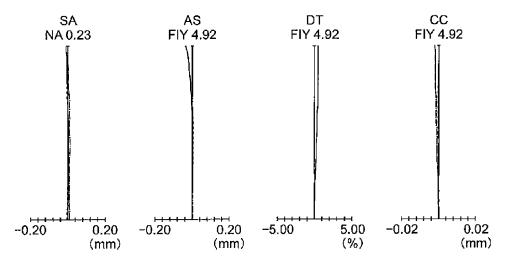


FIG. 28A

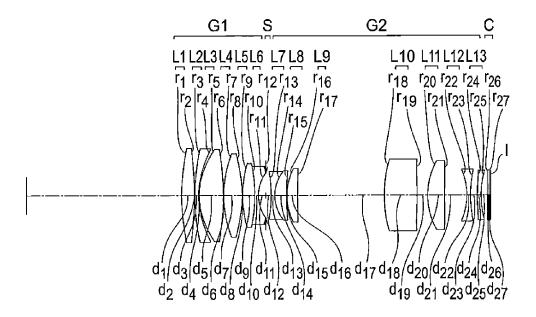


FIG.28B FIG.28C FIG.28D FIG.28E

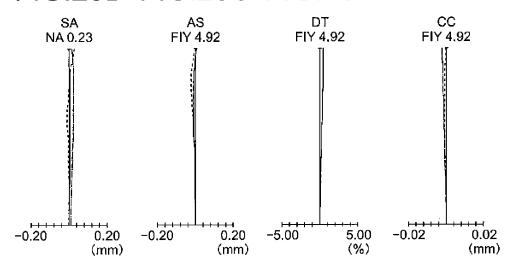


FIG. 29A

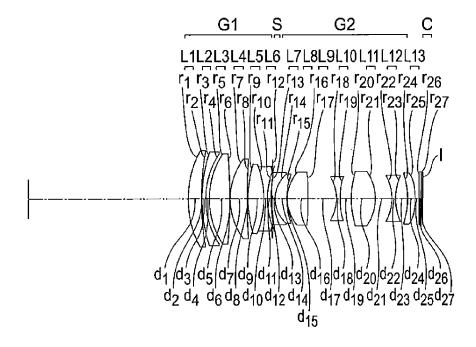


FIG.29B FIG.29C FIG.29D FIG.29E

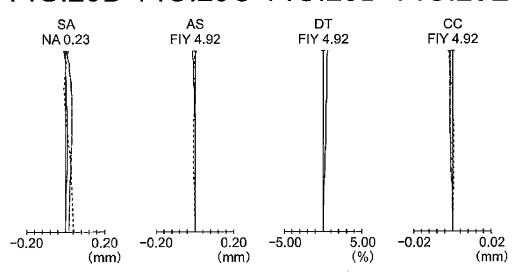


FIG. 30A

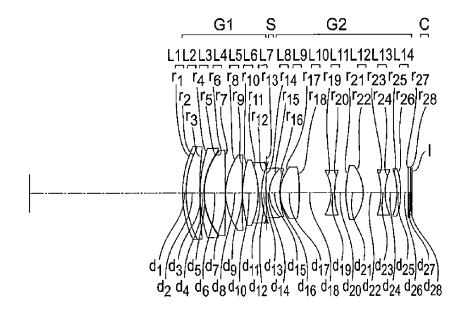


FIG.30B FIG.30C FIG.30D FIG.30E

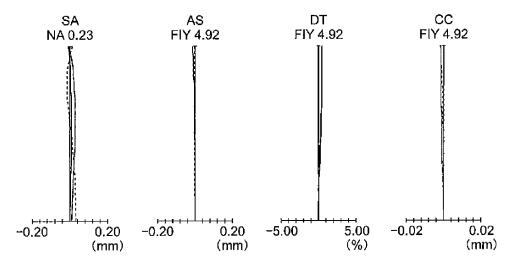


FIG. 31A

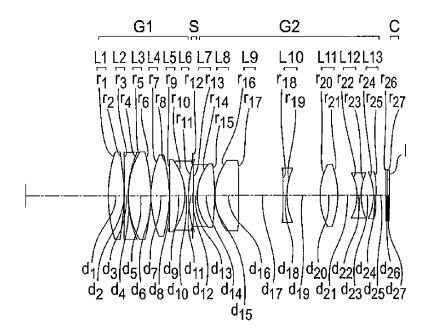


FIG.31B FIG.31C FIG.31D FIG.31E

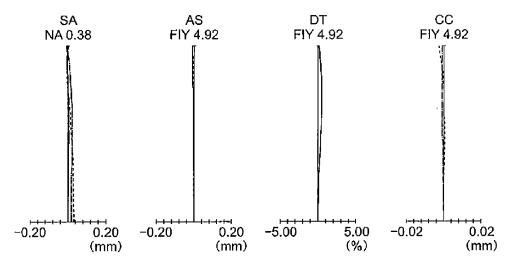


FIG. 32A

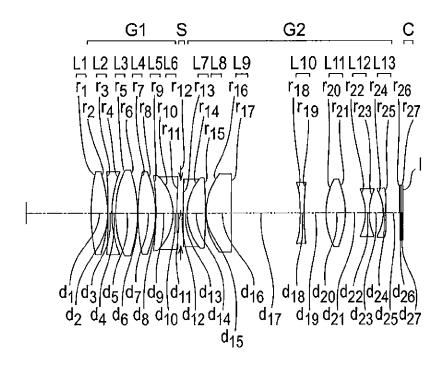


FIG.32B FIG.32C FIG.32D FIG.32E

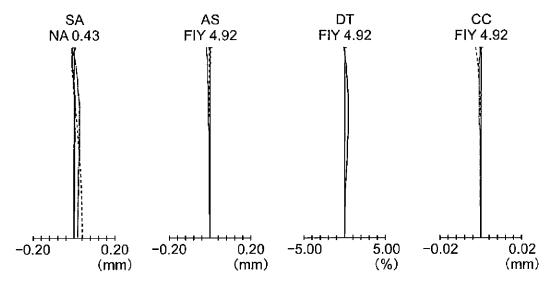


FIG. 33A

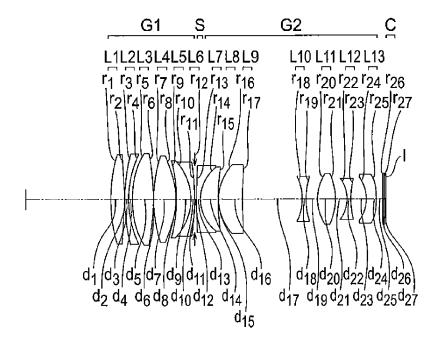


FIG.33B FIG.33C FIG.33D FIG.33E

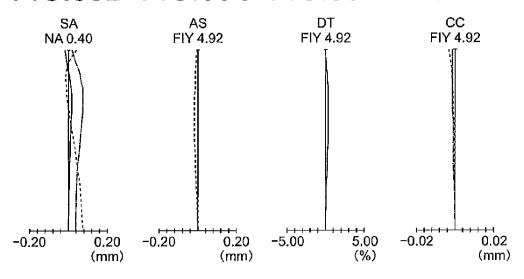


FIG. 34A

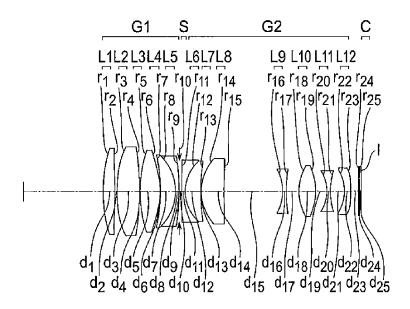


FIG.34B FIG.34C FIG.34D FIG.34E

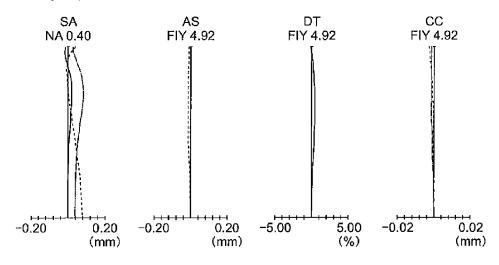


FIG. 35A

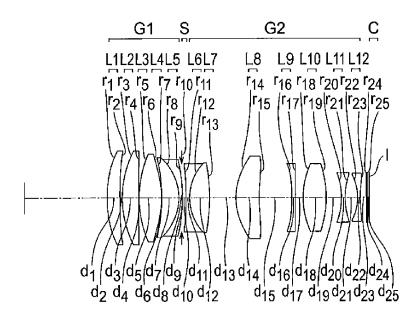


FIG.35B FIG.35C FIG.35D FIG.35E

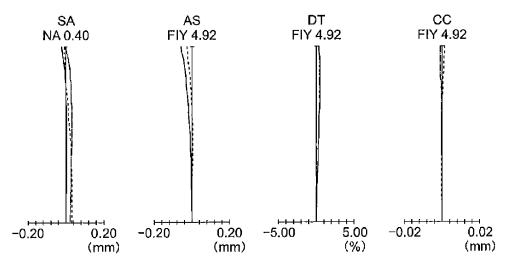


FIG. 36A

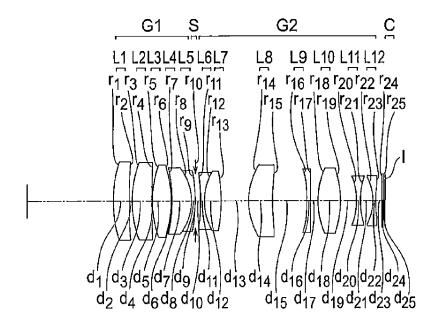


FIG.36B FIG.36C FIG.36D FIG.36E

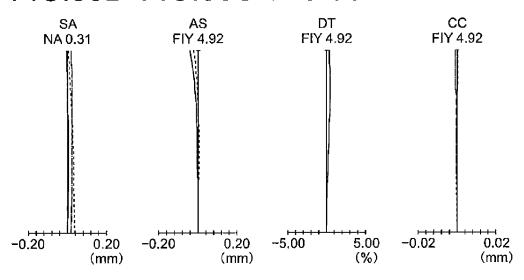


FIG. 37A

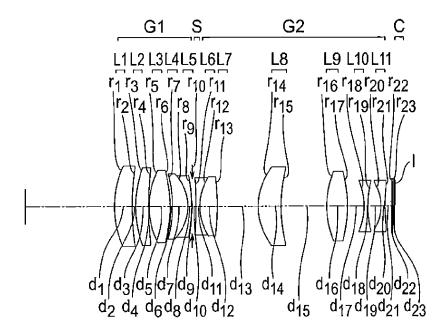


FIG.37B FIG.37C FIG.37D FIG.37E

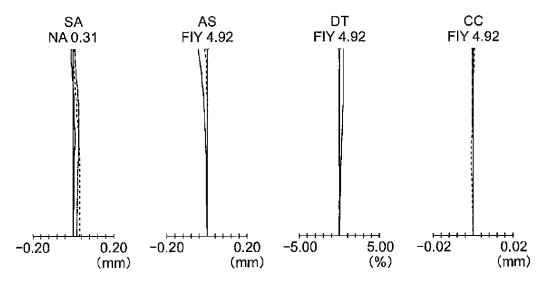


FIG. 38A

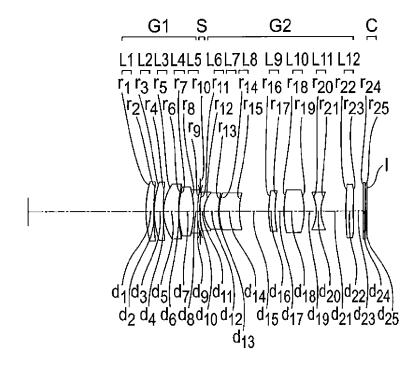


FIG.38B FIG.38C FIG.38D FIG.38E

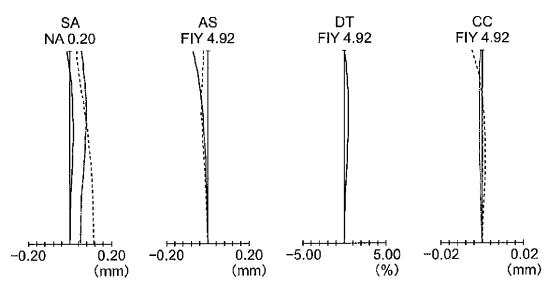


FIG. 39A

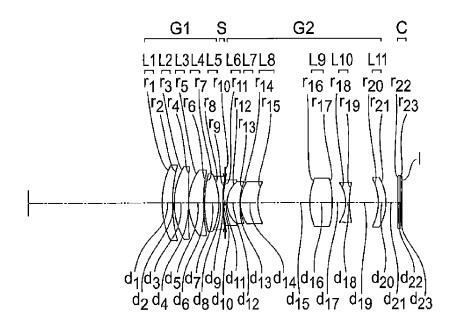


FIG.39B FIG.39C FIG.39D FIG.39E

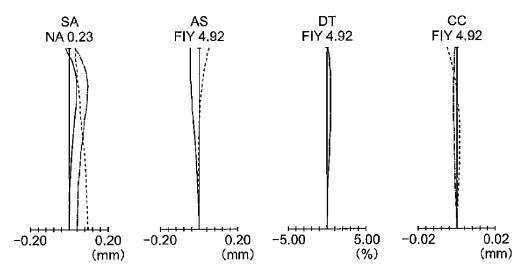


FIG. 40A

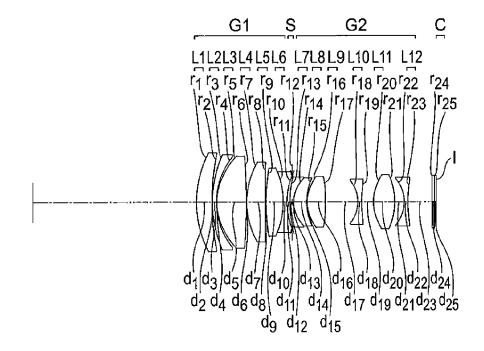


FIG.40B FIG.40C FIG.40D FIG.40E

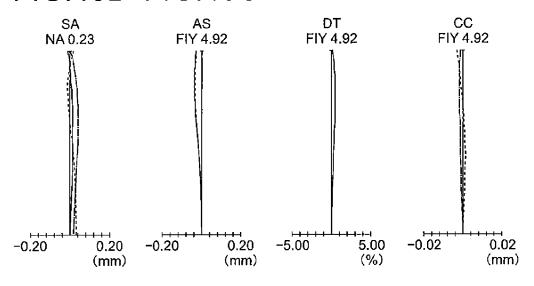


FIG. 41A

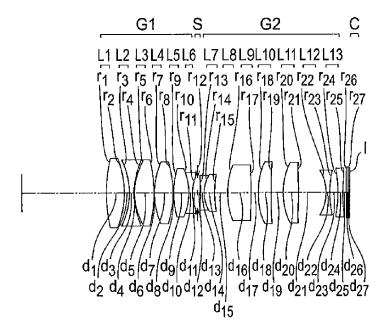


FIG.41B FIG.41C FIG.41D FIG.41E

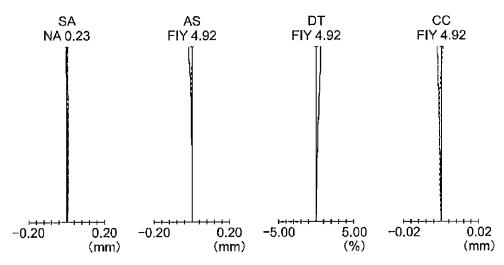


FIG. 42A

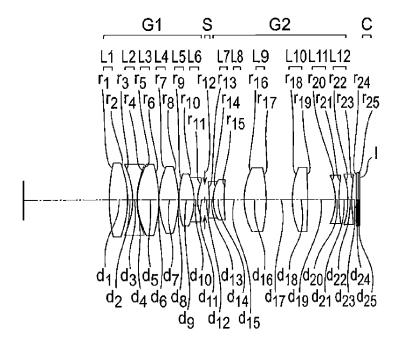


FIG.42B FIG.42C FIG.42D FIG.42E

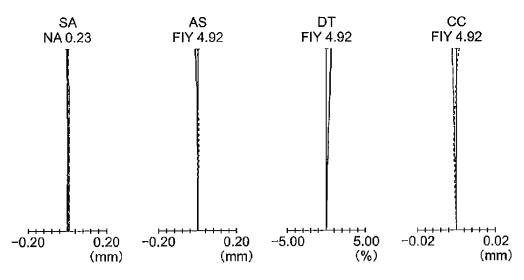


FIG. 43A

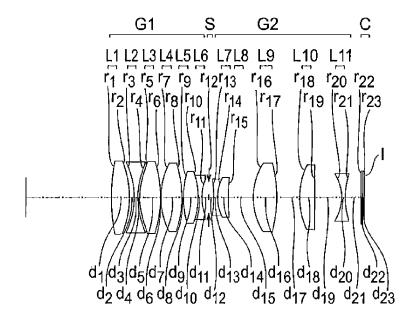


FIG.43B FIG.43C FIG.43D FIG.43E

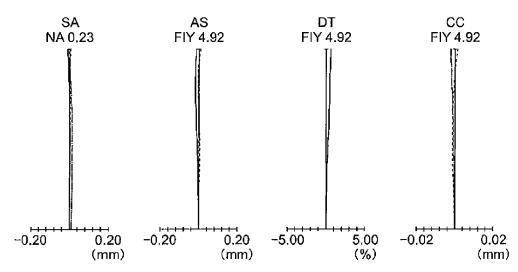


FIG. 44A

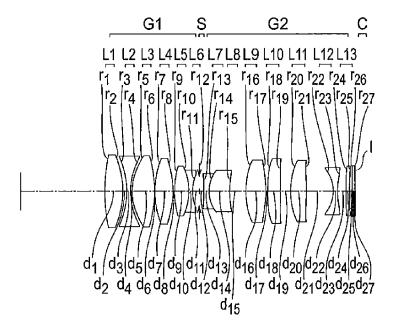


FIG.44B FIG.44C FIG.44D FIG.44E

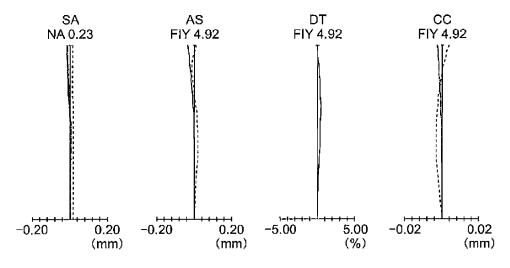


FIG. 45A

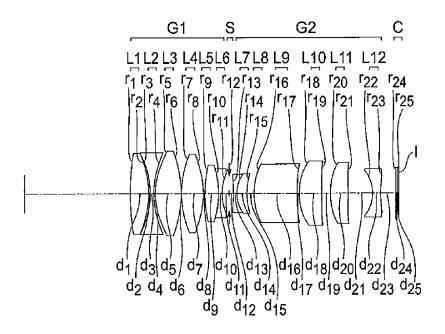


FIG.45B FIG.45C FIG.45D FIG.45E

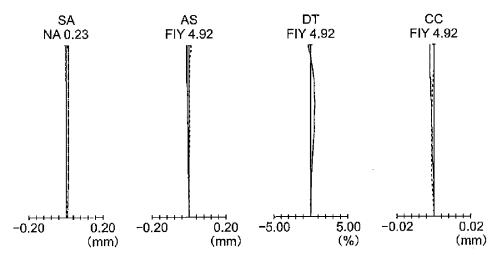


FIG. 46A

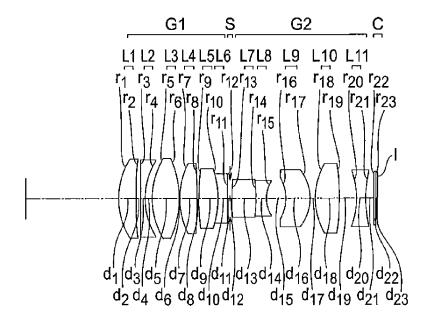


FIG.46B FIG.46C FIG.46D FIG.46E

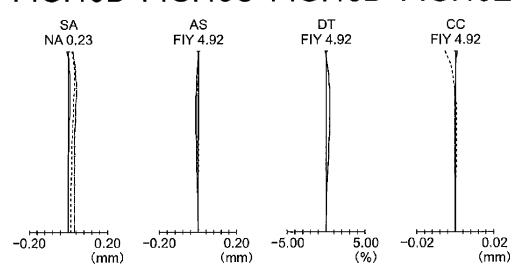


FIG. 47A

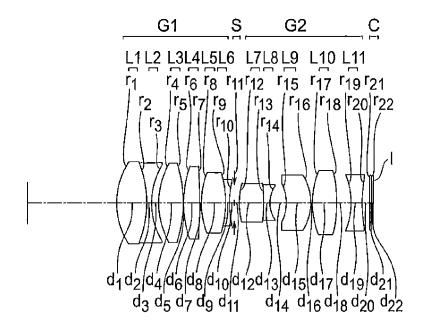


FIG.47B FIG.47C FIG.47D FIG.47E

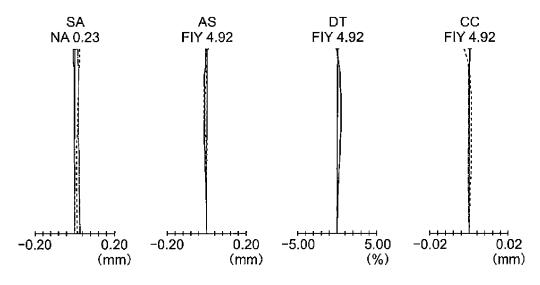


FIG. 48A

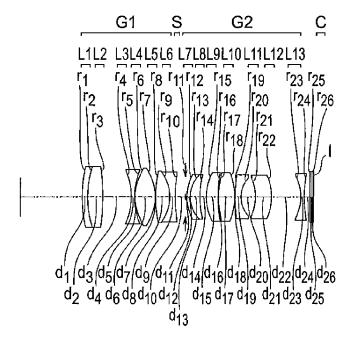


FIG.48B FIG.48C FIG.48D FIG.48E

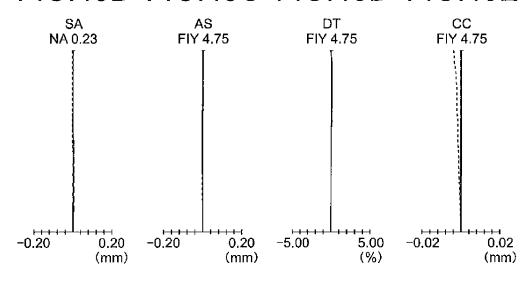


FIG. 49A

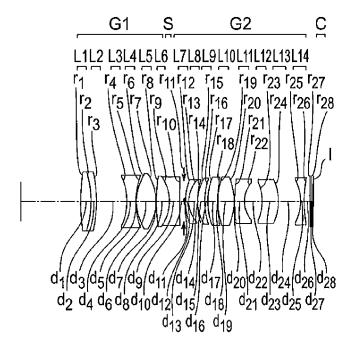


FIG.49B FIG.49C FIG.49D FIG.49E

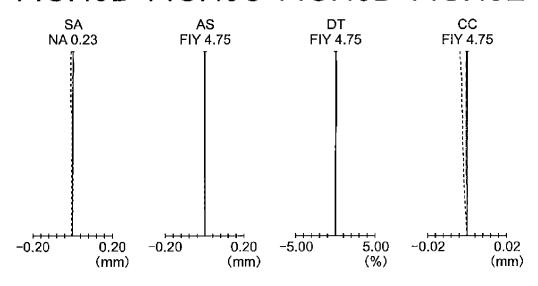


FIG. 50A

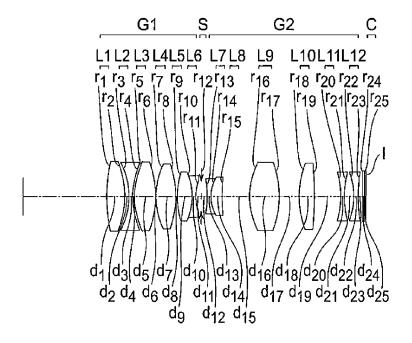


FIG.50B FIG.50C FIG.50D FIG.50E

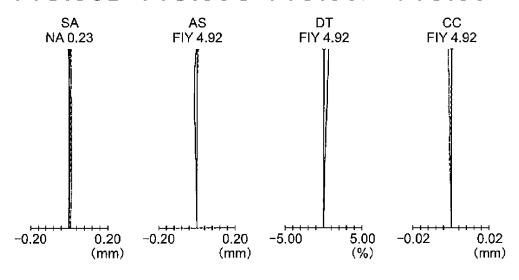


FIG. 51A

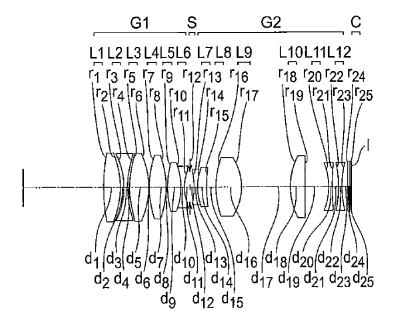


FIG.51B FIG.51C FIG.51D FIG.51E

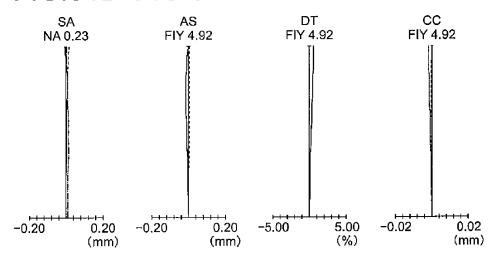


FIG. 52A

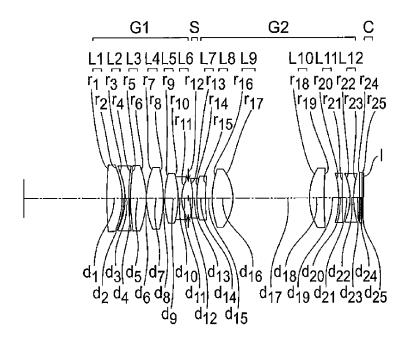


FIG.52B FIG.52C FIG.52D FIG.52E

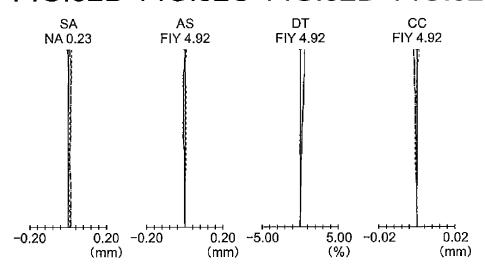


FIG. 53A

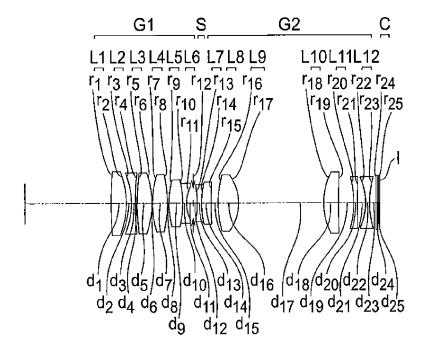


FIG.53B FIG.53C FIG.53D FIG.53E

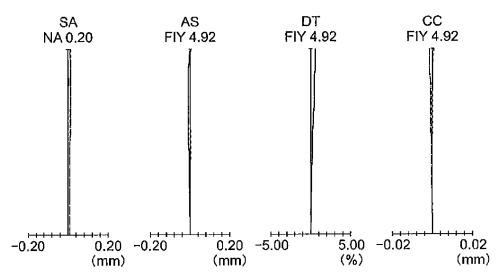


FIG. 54A

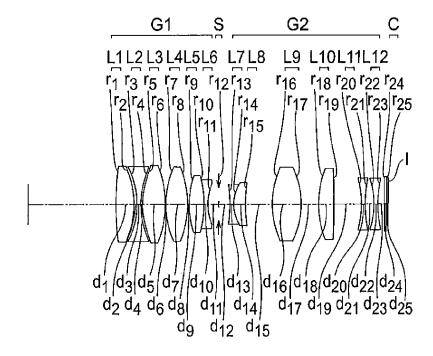


FIG.54B FIG.54C FIG.54D FIG.54E

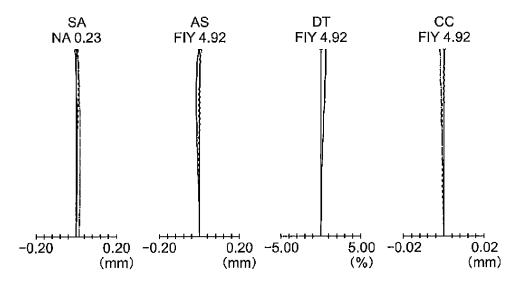


FIG. 55A

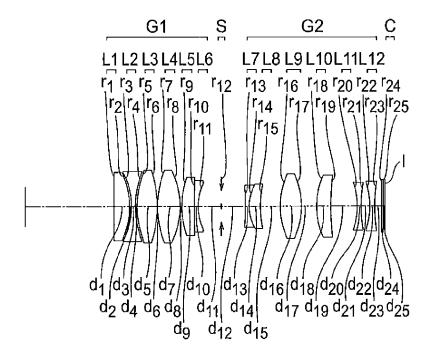


FIG.55B FIG.55C FIG.55D FIG.55E

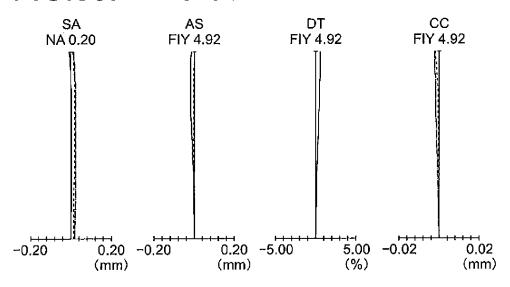


FIG. 56A

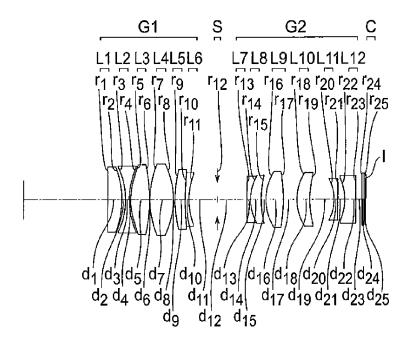


FIG.56B FIG.56C FIG.56D FIG.56E

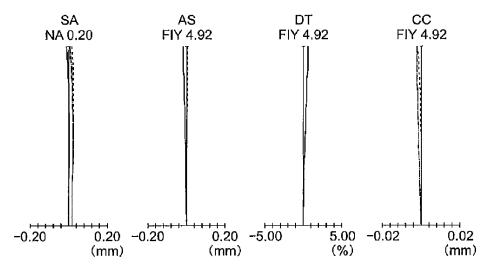


FIG. 57A

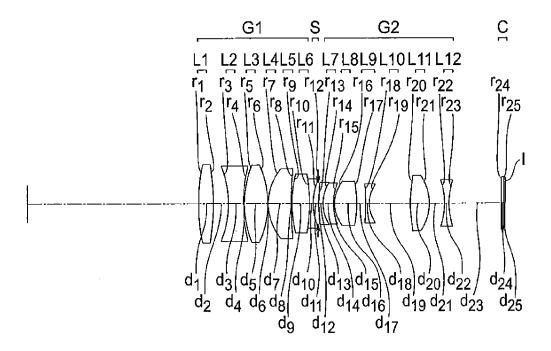


FIG.57B FIG.57C FIG.57D FIG.57E

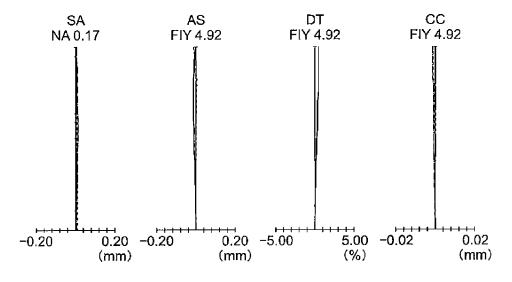


FIG. 58A

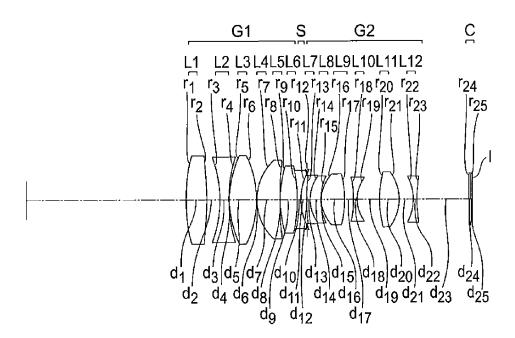


FIG.58B FIG.58C FIG.58D FIG.58E

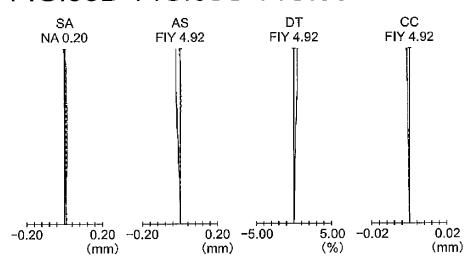


FIG. 59A

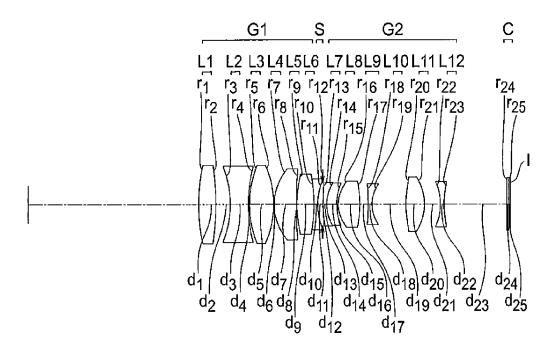


FIG.59B FIG.59C FIG.59D FIG.59E

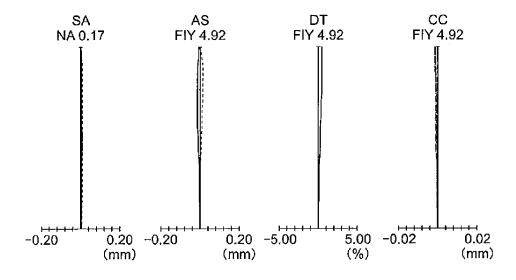


FIG. 60A

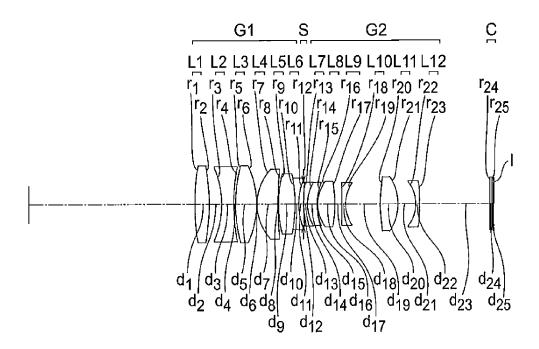


FIG.60B FIG.60C FIG.60D FIG.60E

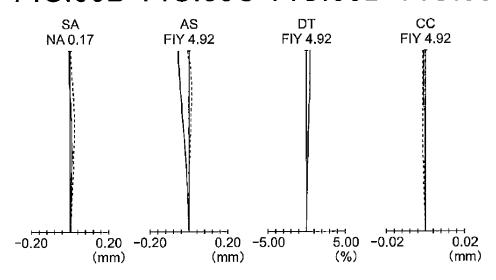


FIG. 61A

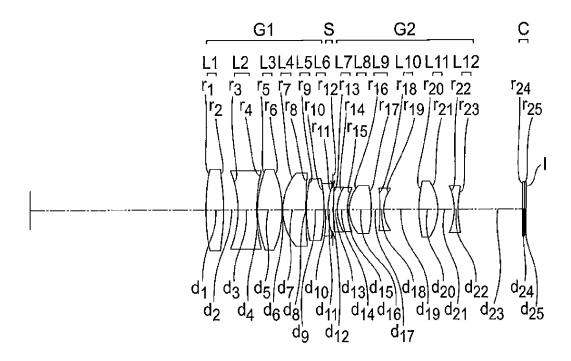


FIG.61B FIG.61C FIG.61D FIG.61E

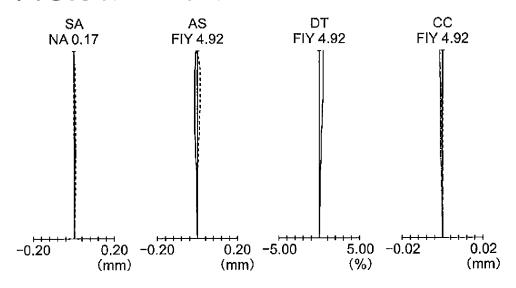


FIG. 62A

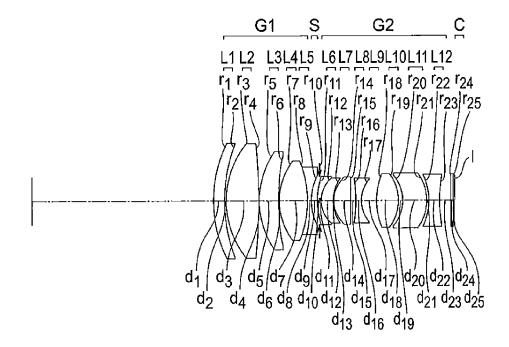


FIG.62B FIG.62C FIG.62D FIG.62E

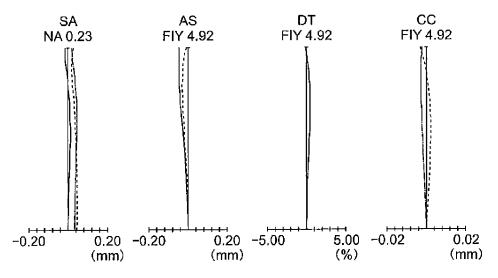


FIG. 63A

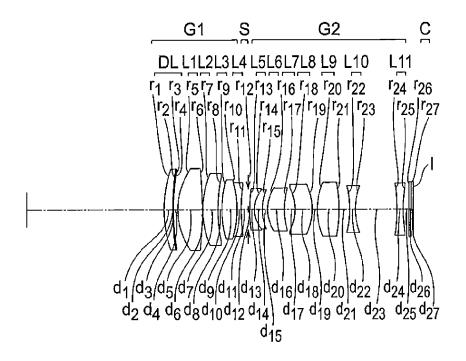


FIG.63B FIG.63C FIG.63D FIG.63E

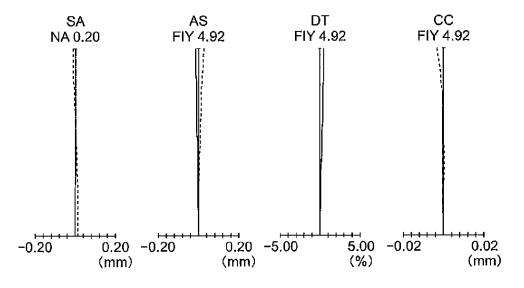


FIG. 64A

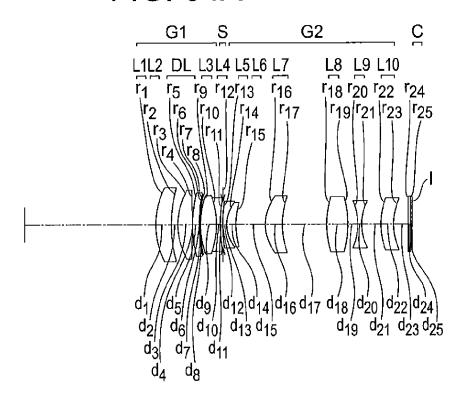


FIG.64B FIG.64C FIG.64D FIG.64E

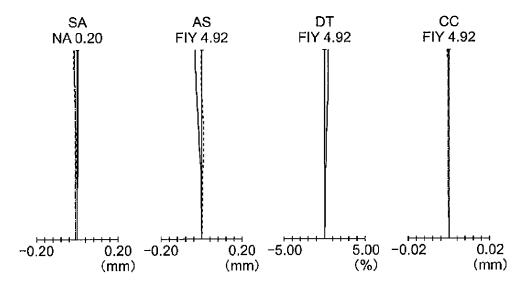


FIG. 65A

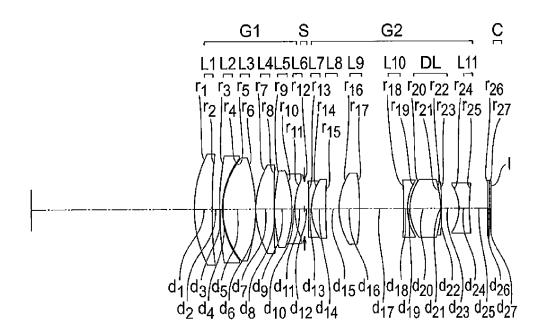


FIG.65B FIG.65C FIG.65D FIG.65E

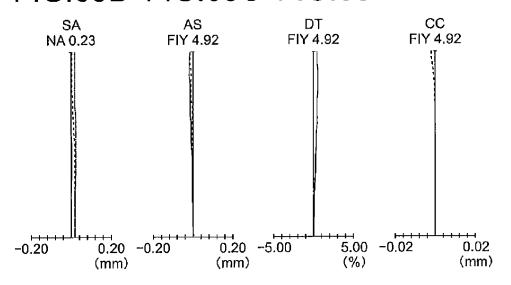


FIG. 66A

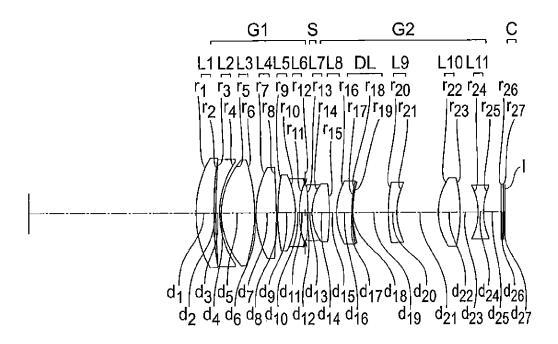


FIG.66B FIG.66C FIG.66D FIG.66E

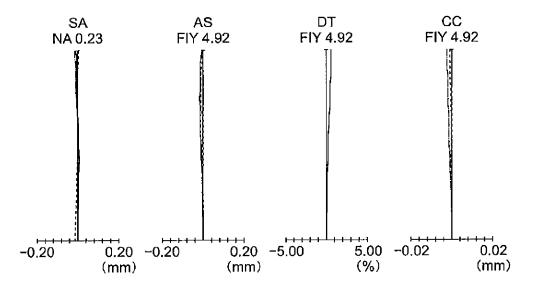


FIG. 67A

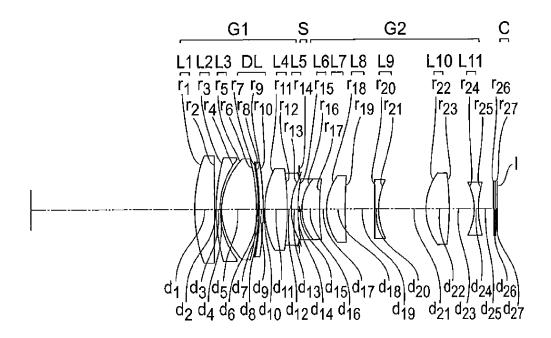


FIG.67B FIG.67C FIG.67D FIG.67E

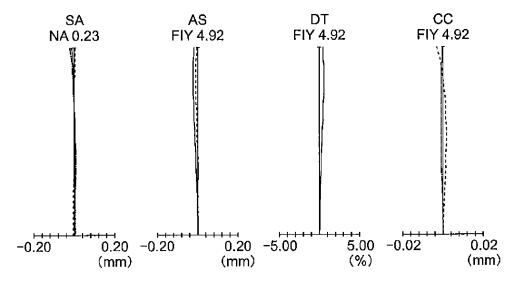


FIG. 68A

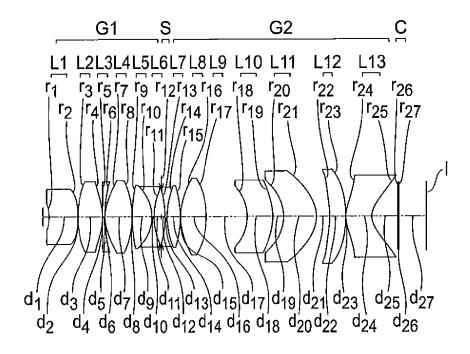


FIG.68B FIG.68C FIG.68D FIG.68E

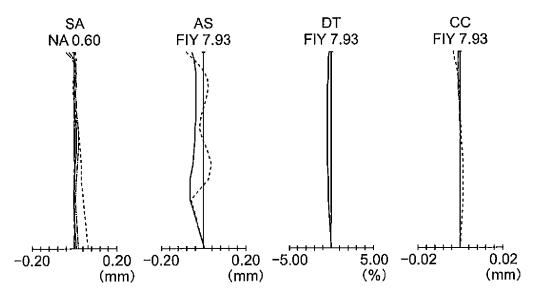


FIG. 69A

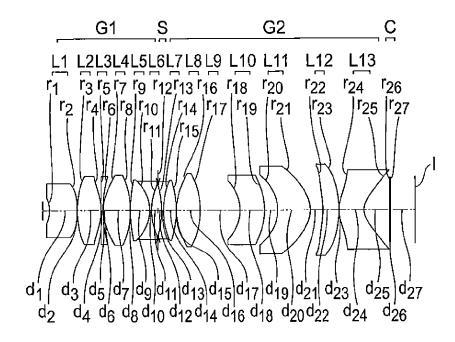


FIG.69B FIG.69C FIG.69D FIG.69E

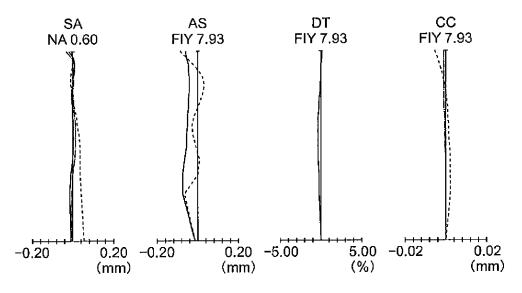


FIG. 70A

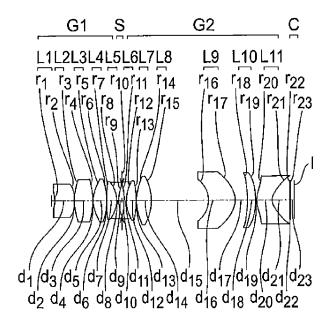


FIG.70B FIG.70C FIG.70D FIG.70E

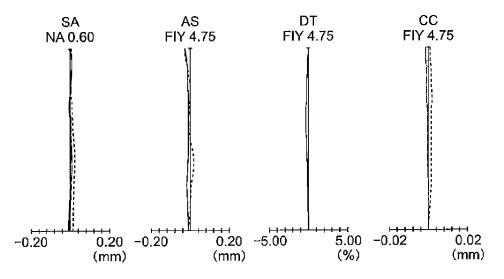


FIG. 71A

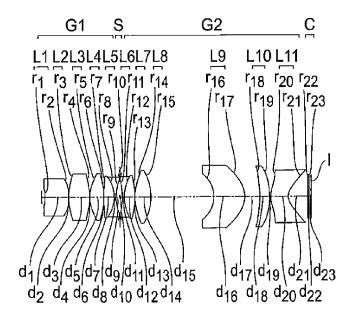


FIG.71B FIG.71C FIG.71D FIG.71E

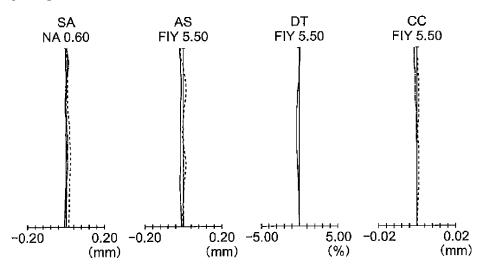


FIG. 72A

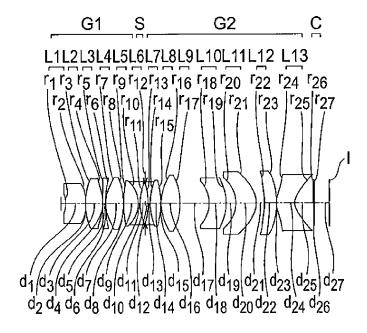


FIG.72B FIG.72C FIG.72D FIG.72E

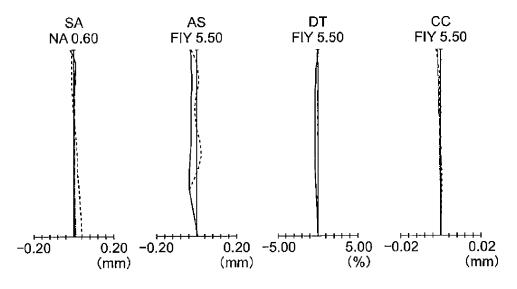


FIG. 73A

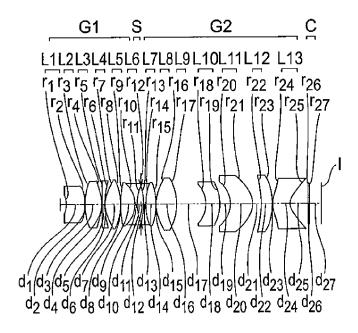


FIG.73B FIG.73C FIG.73D FIG.73E

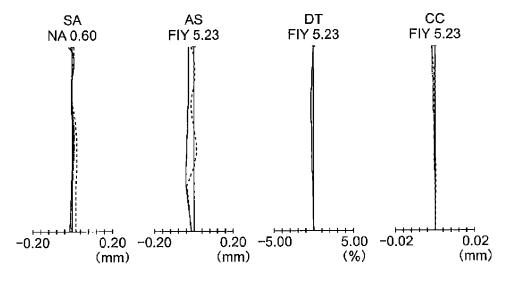


FIG. 74A

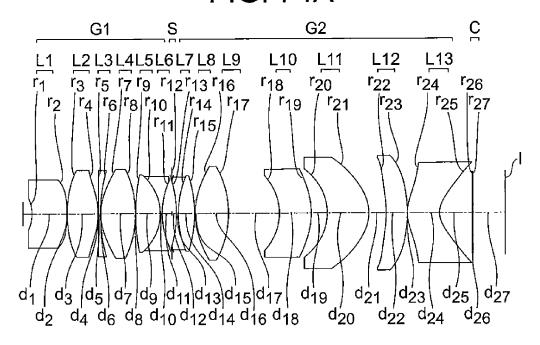


FIG.74B FIG.74C FIG.74D FIG.74E

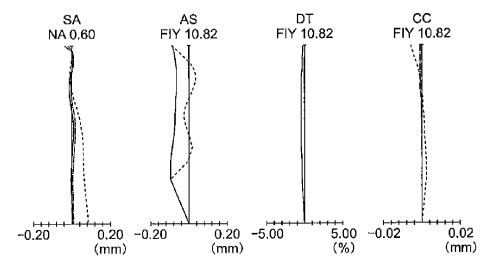


FIG. 75A

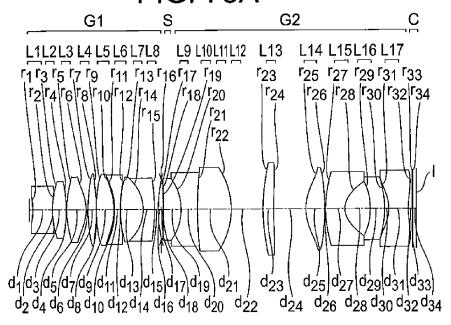


FIG.75B FIG.75C FIG.75D FIG.75E

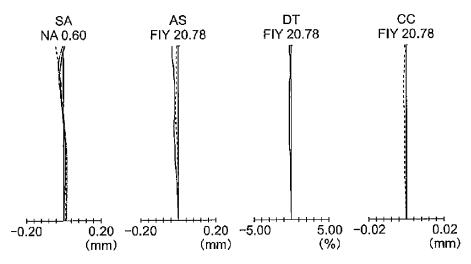


FIG. 76A G1 G2 С L1L2L3L4 L5 L6L7L8 L9L10L11L12L13 L14 L15L16 L17 r₂₅ r₂₇ r₂₉ r₃₁ r₃₃ [1 ^r3 ^r5 ^r7 ^r9 [11 ^r13 ^r16 ^r17 ^r19 ^r23 \r2\r4\r6\r8\r10\r12\r14\\/\r18\/\r20\\r24 |r₂₆ |r₂₈ |r₃₀ |r₃₂ |r₃₄ $d_1/d_3/d_5/d_7/d_9/d_{11}/d_{13}/d_{15}/d_{17}/d_{19}/d_{21}) d_{23}/ d_{25}/d_{27}/d_{29}/d_{31}/d_{33}$ $d_2\,d_4\,d_6\,d_8\,d_{10}\,d_{12}d_{14}\,d_{16}\,d_{18}\,d_{20}d_{22}\,d_{24}\,d_{26}\,d_{28}\,d_{30}\,d_{32}d_{34}$

FIG.76B FIG.76C FIG.76D FIG.76E

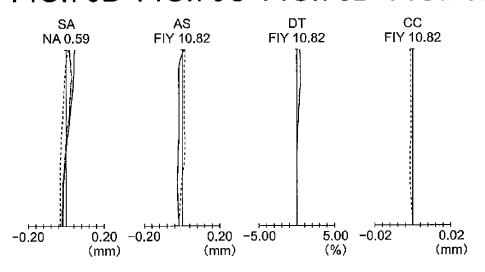


FIG. 77A

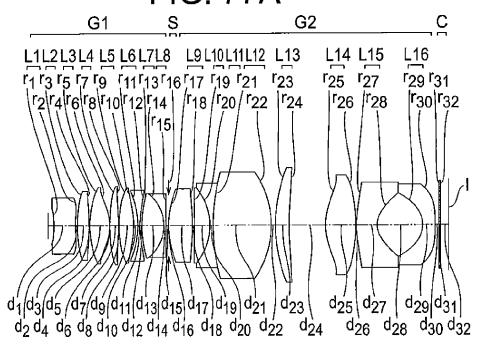


FIG.77B FIG.77C FIG.77D FIG.77E

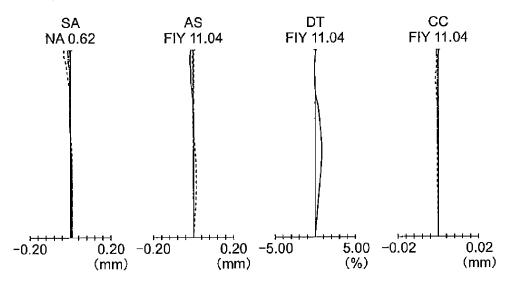


FIG. 78A G2 С G1 L1 L2 L3 L4 L5 L6 L7 L8 L9 L10 L11 L12 L13 L14 L15 ^r21 r₂₃ r₂₅ r₂₇ r₂₉ r1 r3 r5 r7 r9 r11 r14 r15 r17 |r2|r4|r6|r8|r10|r12| /r16/r18 |r₂₄ |r₂₆ |r₂₈|r₃₀ r₂₂ r₂₀ $d_1/d_3/d_5/d_7/d_9/d_{11}/d_{13}/d_{15}/d_{17}/d_{19}/d_{21}$ d₂₃ |d₂₅ d2 d4 d6 d8 d10 d12 d14 d16 d18 d20 d22 $d_{24} d_{26} d_{28} d_{30}$

FIG.78B FIG.78C FIG.78D FIG.78E

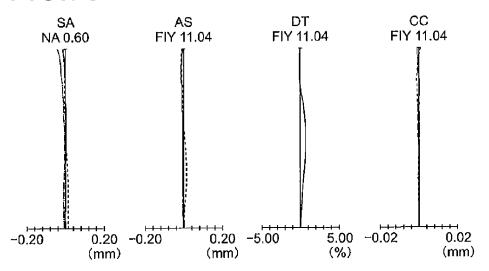


FIG. 79A

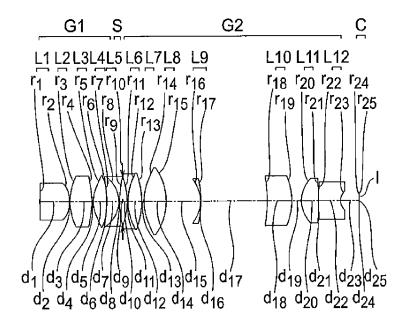


FIG.79B FIG.79C FIG.79D FIG.79E

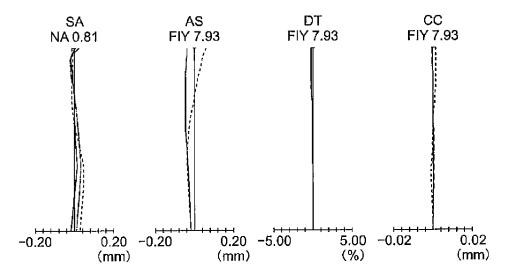


FIG. 80A

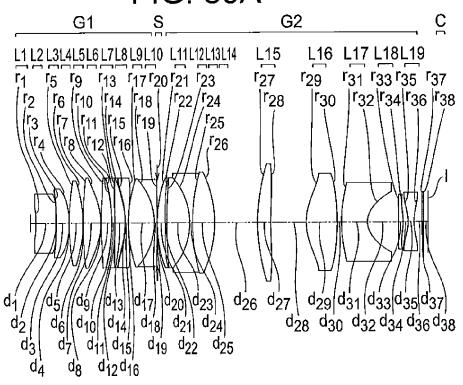


FIG.80B FIG.80C FIG.80D FIG.80E

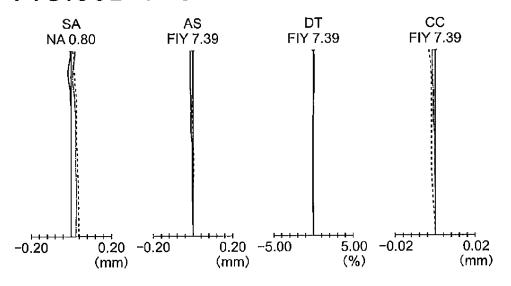


FIG. 81A

G1 S G2 C

L1 L2 L3 L4L5L6 L7L8 L9L10L11L12 L13L14

r1 r3 r5 r7 r9 r12 r13 r16 r20 r22 r24 r26 r28

r2 r4 r6 r8 r10 r14 r17 r21 r23 r25 r27 r29

r11 r11 r15 r18

r12 r4 r6 r8 r10 r14 r17 r21 r23 r25 r27 r29

r14 r6 r8 r10 r11 r15 r18

r15 r7 r9 r12 r13 r16 r20 r22 r24 r26 r28

r2 r4 r6 r8 r10 r14 r17 r21 r23 r25 r27 r29

r14 r6 r8 r10 r11 r15 r18

r15 r17 r21 r23 r25 r27 r29

r24 r26 r28

r25 r27 r29

FIG.81B FIG.81C FIG.81D FIG.81E

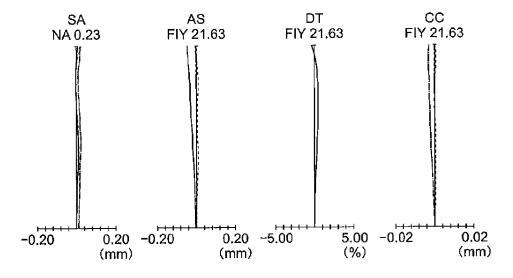


FIG.82B FIG.82C FIG.82D FIG.82E

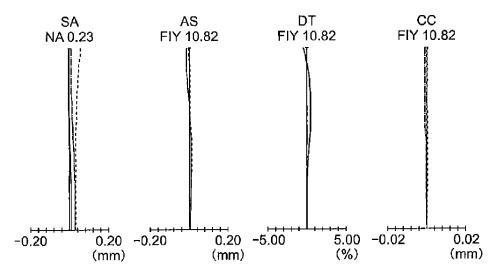


FIG. 83A

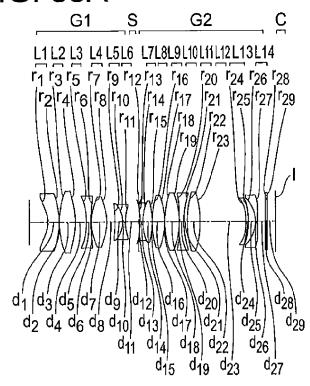


FIG.83B FIG.83C FIG.83D FIG.83E

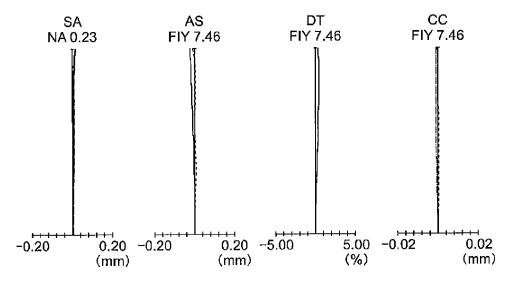


FIG. 84A

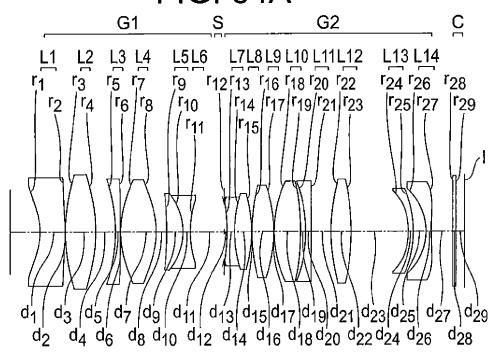


FIG.84B FIG.84C FIG.84D FIG.84E

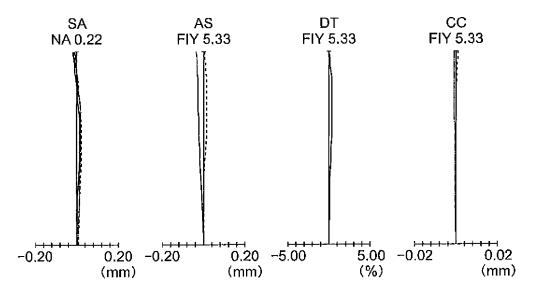


FIG. 85A G1 S G2 L3 L4 L5L6 L7L8L9L10L11L12 L13L14 r9 r12r13 r16 r18 r20 r22 r24 r26 r28 $r_2 | r_4$ /!10 $|\mathbf{r}_6|\mathbf{r}_8$

FIG.85B FIG.85C FIG.85D FIG.85E

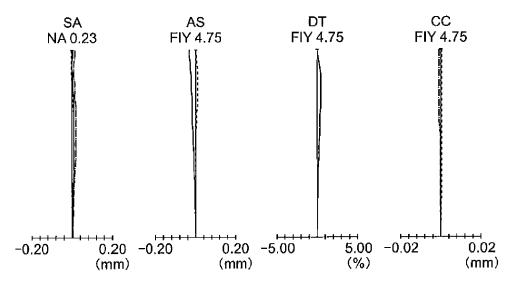


FIG. 86A

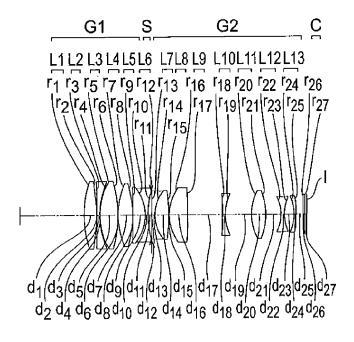


FIG.86B FIG.86C FIG.86D FIG.86E

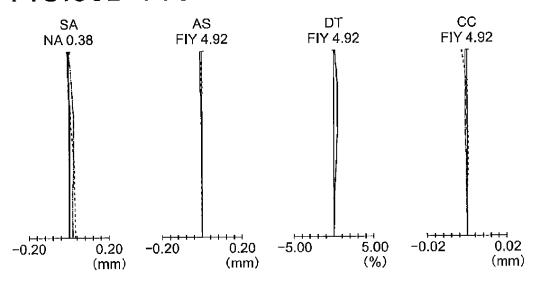


FIG. 87A

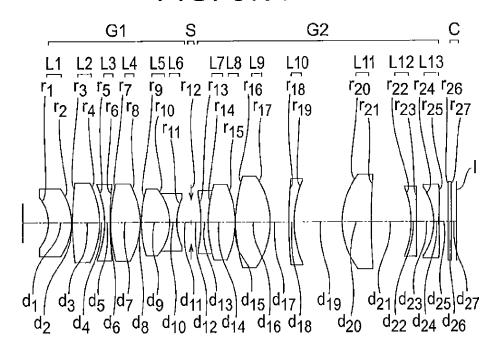


FIG.87B FIG.87C FIG.87D FIG.87E

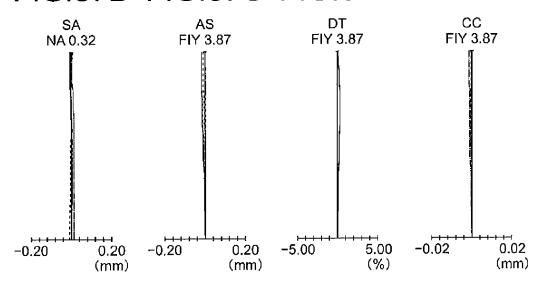


FIG. 88A

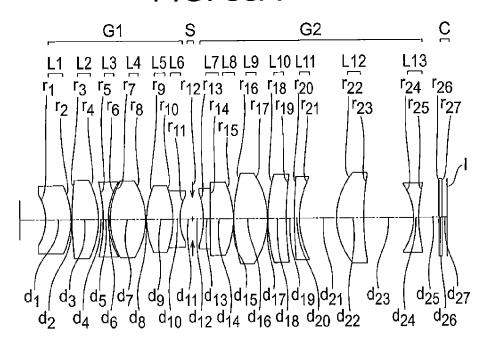


FIG.88B FIG.88C FIG.88D FIG.88E

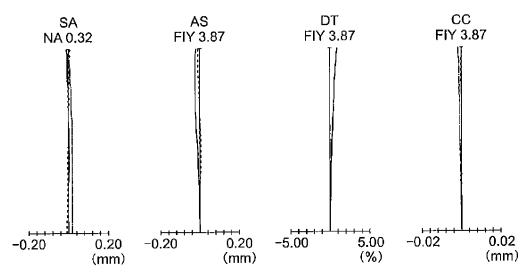


FIG. 89A

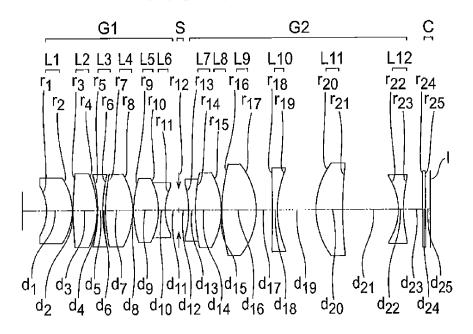


FIG.89B FIG.89C FIG.89D FIG.89E

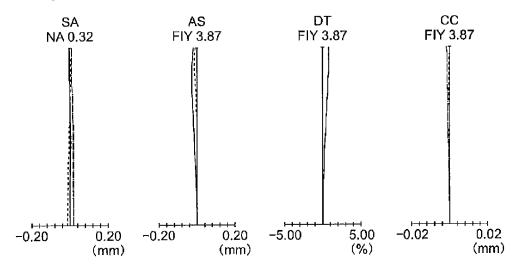


FIG. 90A

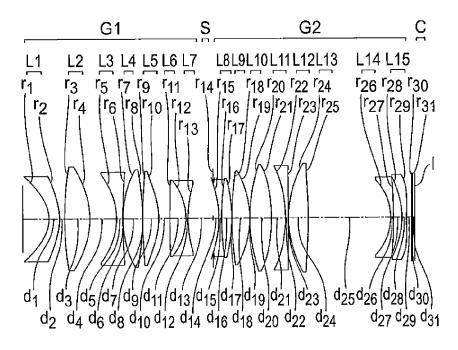


FIG.90B FIG.90C FIG.90D FIG.90E

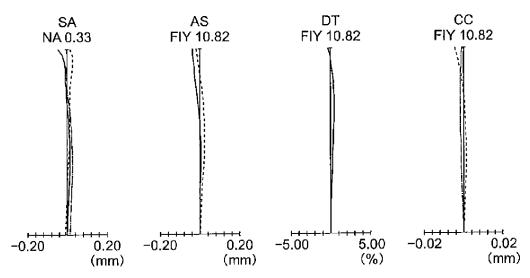


FIG. 91A

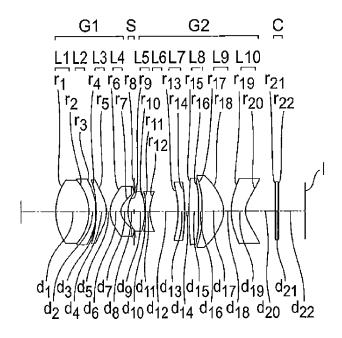


FIG.91B FIG.91C FIG.91D FIG.91E

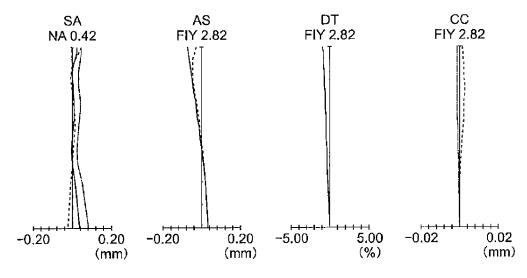


FIG. 92A

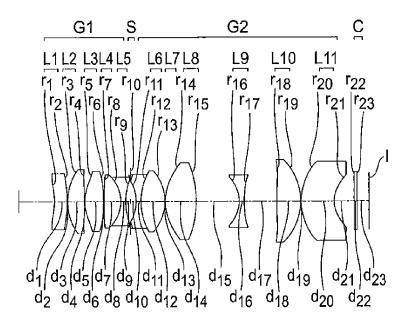


FIG.92B FIG.92C FIG.92D FIG.92E

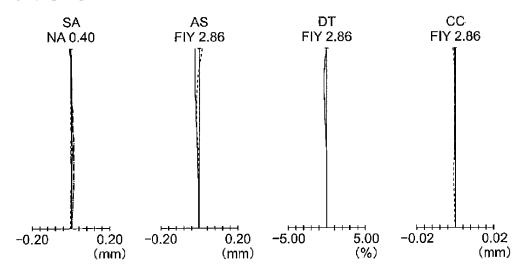


FIG. 93A

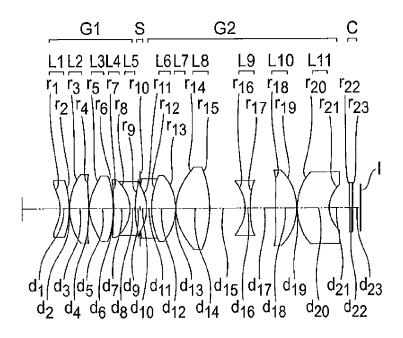


FIG.93B FIG.93C FIG.93D FIG.93E

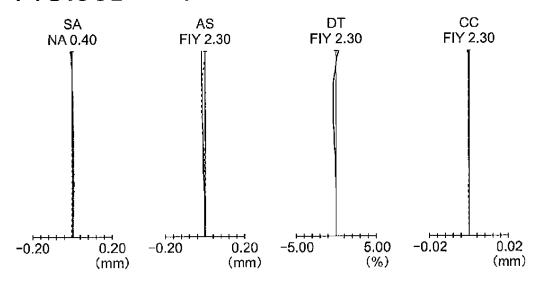


FIG. 94A

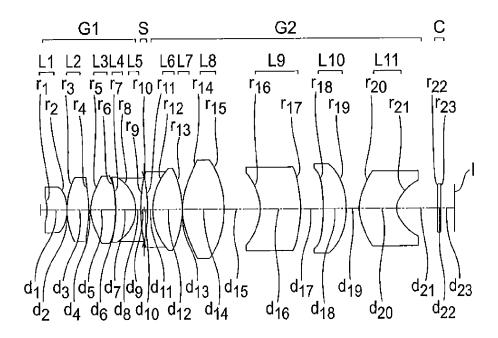


FIG.94B FIG.94C FIG.94D FIG.94E

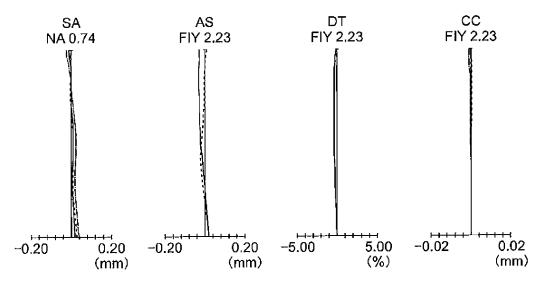


FIG. 95A

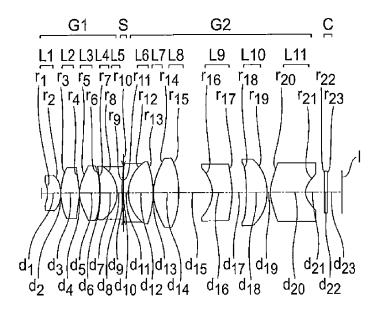


FIG.95B FIG.95C FIG.95D FIG.95E

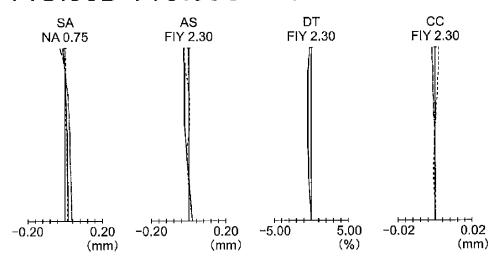


FIG. 96A

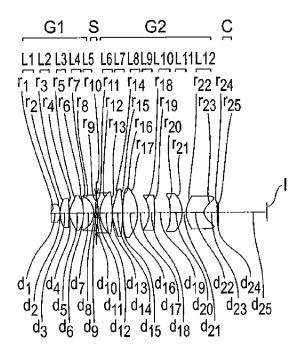


FIG.96B FIG.96C FIG.96D FIG.96E

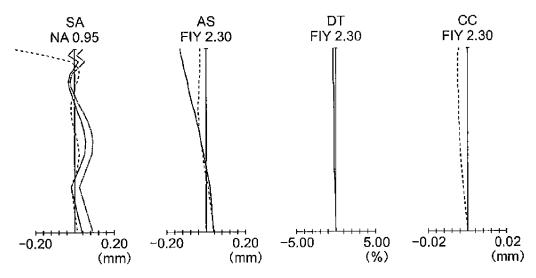


FIG. 97A

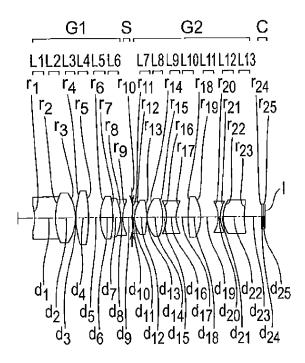


FIG.97B FIG.97C FIG.97D FIG.97E

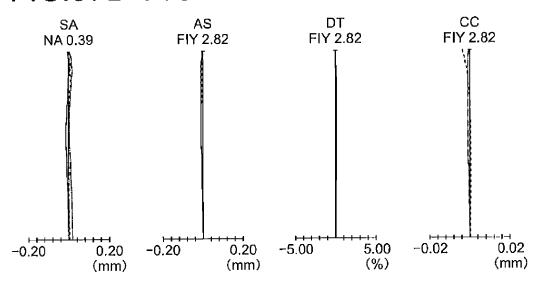


FIG. 98A

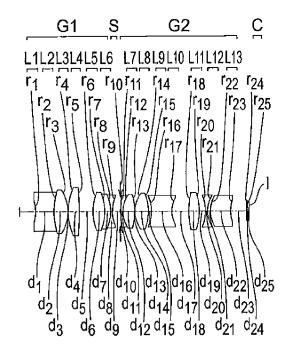


FIG.98B FIG.98C FIG.98D FIG.98E

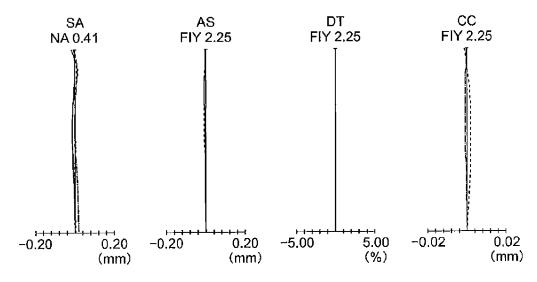


FIG. 99A

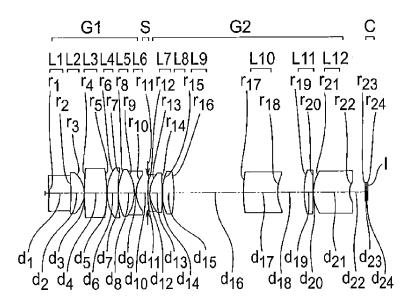


FIG.99B FIG.99C FIG.99D FIG.99E

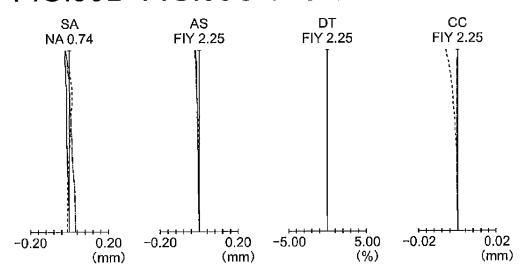


FIG. 100A

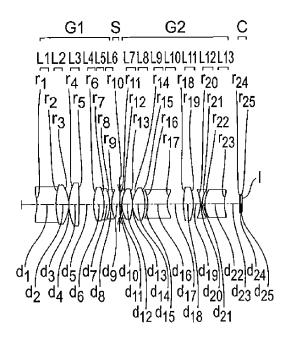


FIG.100B FIG.100C FIG.100D FIG.100E

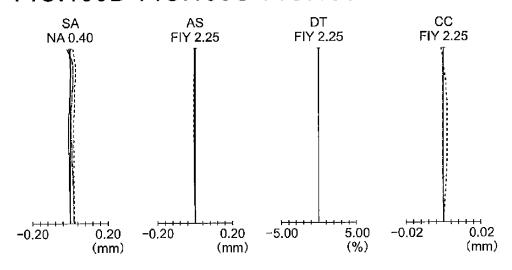


FIG. 101A

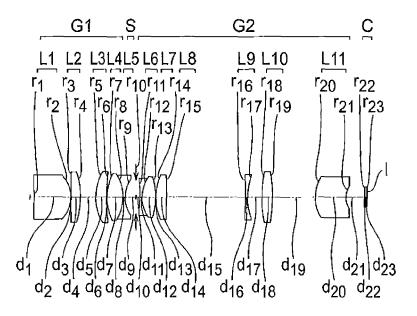


FIG.101B FIG.101C FIG.101D FIG.101E

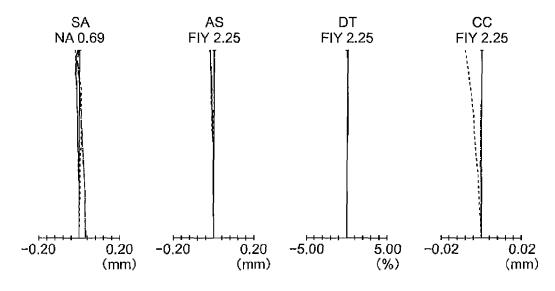


FIG. 102A

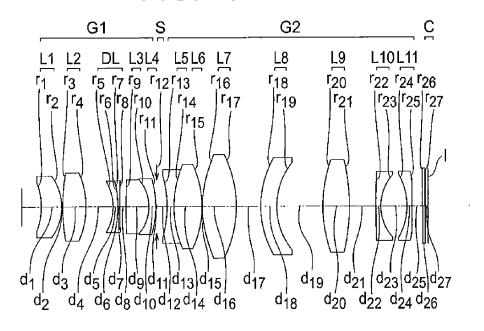


FIG.102B FIG.102C FIG.102D FIG.102E

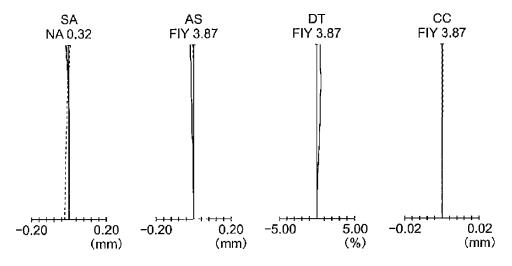


FIG. 103A

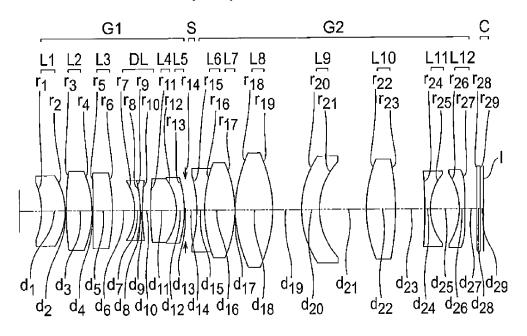


FIG.103B FIG.103C FIG.103D FIG.103E

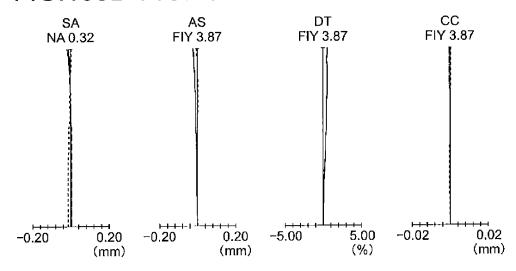


FIG. 104

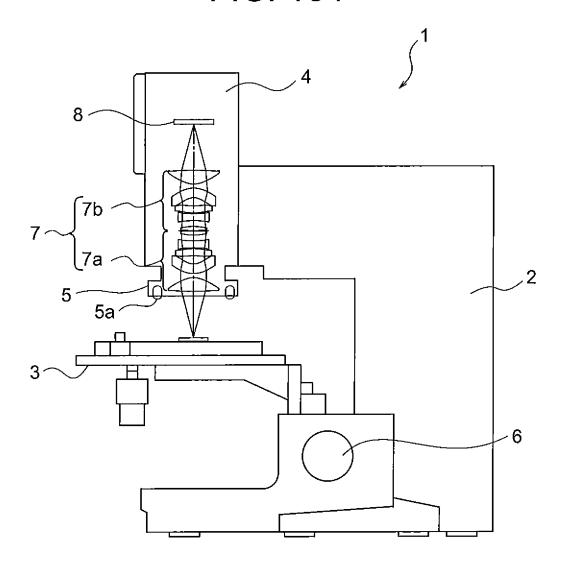


FIG. 105

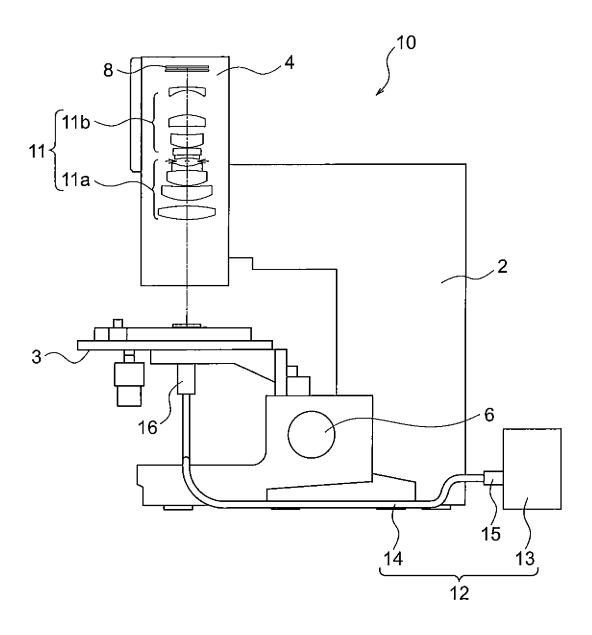


FIG. 106

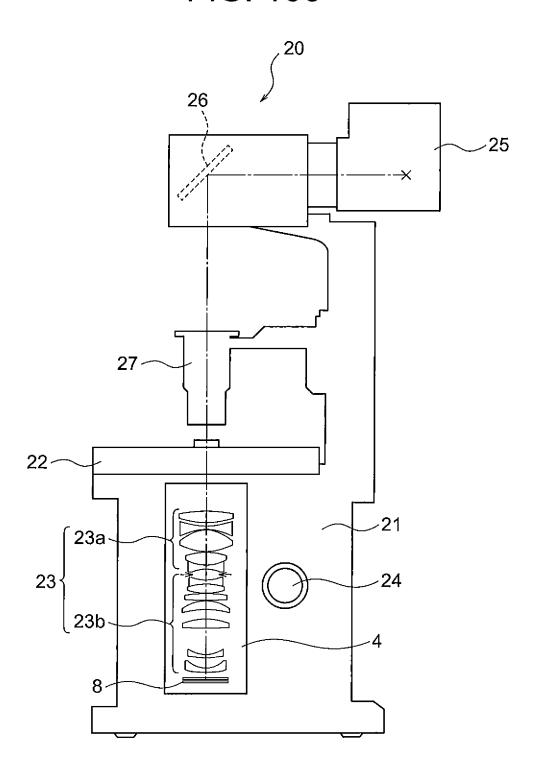


FIG. 107A

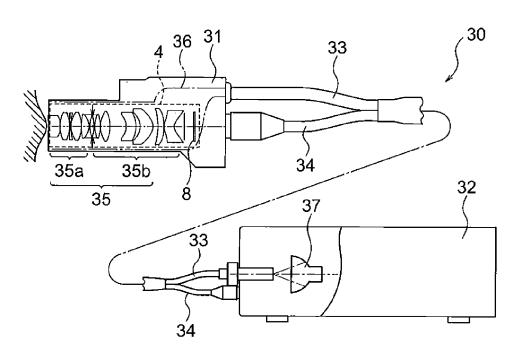
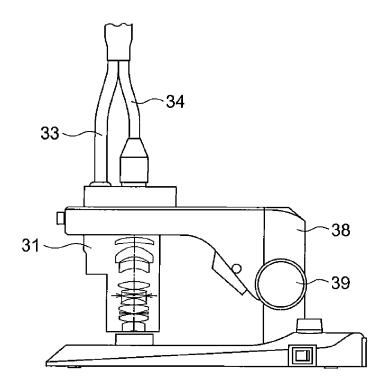


FIG. 107B



OPTICAL SYSTEM AND OPTICAL INSTRUMENT, IMAGE PICKUP APPARATUS, AND IMAGE PICKUP SYSTEM USING THE **SAME**

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation application of PCT/JP2013/075153 filed on Sep. 18, 2013 which is based upon and claims the benefit of priority from Japanese Patent Application No. 2012-208980 filed on Sep. 21, 2012; the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical system, and an optical instrument, an image pickup apparatus, and an image 20 pickup system using the same.

2. Description of the Related Art

In a case of observing a minute sample, a method in which, first, the overall sample is observed, and a region to be observed in detail is identified, and thereafter the region to be 25 observed in detail is magnified and observed, has hitherto been adopted. As an image pickup apparatus to be used in such method, an image pickup apparatus which magnifies digitally an image that has been captured, and displays the magnified image is available. As an optical system to be used 30 in such image pickup apparatus, an optical system described in Japanese Patent Application Laid-open Publication number 2012-173491 is available. Digital magnification of image is called as digital zooming.

systems for microscope, are differentiated according to a difference of a type of image formation, they will be divided into two types namely, optical systems of finite correction type and optical systems of infinite correction type. In the optical system of finite correction type, an object image is 40 formed at a finite distance by a microscope objective. Whereas, in the optical system of infinite correction type, light emerged from the microscope objective becomes a substantially parallel light beam. Therefore, in the optical system of infinite correction type, an object image is formed by 45 combining the microscope objective and a tube lens.

As aforementioned, in a microscope optical system of the infinite correction type, a microscope objective by which, the light emerged becomes substantially parallel light beam, has been used. As an example of the microscope objective, a 50 microscope objective described in Japanese Patent Application Laid-open Publication No. 2008-185965 is available. The microscope objective described in Japanese Patent Application Laid-open Publication No. 2008-185965 has a numerical aperture (NA) of an extremely large value on an 55 object side (sample side), such that a numerical aperture on the object side is 0.8. This microscope objective is used with the tube lens, and at this time, if a numerical aperture on an image side is small, a bright and sharp image cannot be formed.

SUMMARY OF THE INVENTION

An optical system according to an aspect of the present invention is an optical system which forms an optical image 65 on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light

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intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit having a positive refractive power, which 5 includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first 10 lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens,

the following conditional expressions (15), (16), (19), and (20) are satisfied:

$$\beta \leq -1.1 \tag{15}$$

$$0.08 < NA$$
 (16)

$$1.0 < WD/BF \tag{19}$$

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obi})/\phi_s \le 4.0$$
 (20)

where.

β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the optical system,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens,

BF denotes a distance on the optical axis from an image-Moreover, if conventional optical systems, such as optical 35 side surface of the second image-side lens up to the image,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

Moreover, an optical system according to another aspect of the present invention is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts alight intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit which includes a plurality of lenses, a stop, and

a second lens unit which includes a plurality of lenses,

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (21), (23-1), and (24-1) are satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

$$0.6 \le L_L/D_{oi}$$
 (23-1)

$$0.015 \le 1/\nu d_{min} - 1/\nu d_{max}$$
 (24-1)

where.

60

NA denotes a numerical aperture on the object side of the optical system,

 ${\rm D}_{max}$ denotes a maximum distance from among distances on an optical axis of adjacent lenses in the optical system,

 ϕ_s denotes a diameter of the stop,

 L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side 5 surface of the second image-side lens,

 \mathbf{D}_{ot} denotes a distance on the optical axis from the object to the image,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

 vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system.

An optical system according to still another aspect of the present invention comprising in order from an object side,

a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and

the following conditional expressions (4-1), (5), (9-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_1 / \Sigma d < 0.2$$
 (9-1)

$$-20 < \Delta f_{cd} < d < 20 \tag{13}$$

where

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

 β denotes a projection magnification of the optical system,

 ${\rm d_1}$ denotes a distance on an optical axis from a surface positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr,

Σd denotes a sum total of lens thickness on the optical axis of an overall optical system,

 ϵ d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

Moreover, an optical system according to still another aspect of the present invention comprising in order from an object side,

a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and

the following conditional expression (4-1), (5), (10-1), and (13) are satisfied:

$$-2 < \beta < -0.5 \tag{5}$$

$$0 < d_2 / \Sigma d < 2$$
 (10-1)

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the 65 optical system,

 β denotes a projection magnification of the optical system,

4

d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

ed denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

Moreover, an optical system according to still another aspect of the present invention is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 μm, comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (18), and (25) are satisfied:

$$0.08 < NA$$
 (16)

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \epsilon_d < 30$$

$$(18)$$

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

NA denotes a numerical aperture on the object side of the optical system,

 $\Delta D_{G1dC} \ \ denotes \ a \ distance \ from \ a \ position \ of \ an \ image \ point \ P_{G1} \ on \ a \ d-line \ up to \ a \ position \ of \ an \ image \ point \ on \ a$ $\ C-line, \ at \ an \ image \ point \ of \ the \ first \ lens \ unit \ with \ respect \ to \ an \ object \ point \ on \ an \ optical \ axis,$

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the 50 image point P_{G1} is let to be an object point of the second lens unit.

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system,

 \mathbf{D}_{os} denotes a distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object up to the image, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

Moreover, a microscope which is an example of an optical instrument of the present invention, or an image pickup apparatus of the present invention comprises, the optical system described above, and an image pickup element.

Furthermore, an image pickup system of the present invention comprises, the image pickup apparatus described above, a stage which holds an object, and an illuminating unit which illuminates the object.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 1;

FIG. **2**A, FIG. **2**B, FIG. **2**C, and FIG. **2**D are diagrams 20 showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 1;

FIG. 3 is a cross-sectional view along an optical axis show- 25 ing an optical arrangement of an optical system according to an example 2;

FIG. 4A, FIG. 4B, FIG. 4C, and FIG. 4D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification 30 (CC) respectively, of the optical system according to the example 2;

FIG. 5 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 3;

FIG. 6A, FIG. 6B, FIG. 6C, and FIG. 6D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 3;

FIG. 7 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 4;

FIG. **8**A, FIG. **8**B, FIG. **8**C, and FIG. **8**D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a 45 distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 4;

FIG. 9 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to 50 an example 5;

FIG. 10A, FIG. 10B, FIG. 10C, and FIG. 10D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the 55 example 5;

FIG. 11 is a cross-sectional view along an optical axis showing an optical arrangement of an optical system according to an example 6;

FIG. 12A, FIG. 12B, FIG. 12C, and FIG. 12D are diagrams 60 showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 6;

FIG. 13 is a cross-sectional view along an optical axis 65 showing an optical arrangement of an optical system according to an example 7;

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FIG. 14A, FIG. 14B, FIG. 14C, and FIG. 14D are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to the example 7;

FIG. 15A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 15B, FIG. 15C, FIG. 15D, and FIG. 15E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 8;

FIG. **16**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **16**B, FIG. **16**C, FIG. **16**D, and FIG. **16**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 9;

FIG. 17A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 17B, FIG. 17C, FIG. 17D, and FIG. 17E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 10;

FIG. **18**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **18**B, FIG. **18**C, FIG. **18**D, and FIG. **18**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 11;

FIG. **19**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **19**B, FIG. **19**C, FIG. **19**D, and FIG. **19**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 12;

FIG. **20**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **20**B, FIG. **20**C, FIG. **20**D, and FIG. **20**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 13;

FIG. 21A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 21B, FIG. 21C, FIG. 21D, and FIG. 21E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 14;

FIG. 22A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 22B, FIG. 22C, FIG. 22D, and FIG. 22E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 15;

FIG. 23A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 23B, FIG. 23C, FIG. 23D, and FIG. 23E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 16;

FIG. 24A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 24B, FIG. 24C, FIG. 24D, and FIG. 24E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 17;

FIG. 25A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 25B, FIG. 25C,

FIG. **25**D, and FIG. **25**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 18;

FIG. **26**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **26**B, FIG. **26**C, FIG. **26**D, and FIG. **26**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 19;

FIG. 27A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 27B, FIG. 27C, FIG. 27D, and FIG. 27E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 15 the optical system according to an example 20;

FIG. **28**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **28**B, FIG. **28**C, FIG. **28**D, and FIG. **28**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 20 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 21;

FIG. **29**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **29**B, FIG. **29**C, FIG. **29**D, and FIG. **29**E are diagrams showing a spherical 25 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 22;

FIG. **30**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **30**B, FIG. **30**C, 30 FIG. **30**D, and FIG. **30**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **23**;

FIG. **31**A is a cross-sectional view along an optical axis 35 showing an optical arrangement, and FIG. **31**B, FIG. **31**C, FIG. **31**D, and FIG. **31**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 24;

FIG. 32A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 32B, FIG. 32C, FIG. 32D, and FIG. 32E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 45 the optical system according to an example 25;

FIG. 33A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 33B, FIG. 33C, FIG. 33D, and FIG. 33E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 50 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 26;

FIG. **34**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **34**B, FIG. **34**C, FIG. **34**D, and FIG. **34**E are diagrams showing a spherical 55 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 27;

FIG. **35**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **35**B, FIG. **35**C, 60 FIG. **35**D, and FIG. **35**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 28;

FIG. **36**A is a cross-sectional view along an optical axis 65 showing an optical arrangement, and FIG. **36**B, FIG. **36**C, FIG. **36**D, and FIG. **36**E are diagrams showing a spherical

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aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 29;

FIG. 37A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 37B, FIG. 37C, FIG. 37D, and FIG. 37E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 30;

FIG. 38A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 38B, FIG. 38C, FIG. 38D, and FIG. 38E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 31;

FIG. **39**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **39**B, FIG. **39**C, FIG. **39**D, and FIG. **39**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 32;

FIG. **40**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **40**B, FIG. **40**C, FIG. **40**D, and FIG. **40**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 33;

FIG. 41A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 41B, FIG. 41C, FIG. 41D, and FIG. 41E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 34;

FIG. **42**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **42**B, FIG. **42**C, FIG. **42**D, and FIG. **42**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **35**;

FIG. **43**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **43**B, FIG. **43**C, FIG. **43**D, and FIG. **43**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 36;

FIG. 44A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 44B, FIG. 44C, FIG. 44D, and FIG. 44E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 37;

FIG. **45**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **45**B, FIG. **45**C, FIG. **45**D, and FIG. **45**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **38**;

FIG. **46**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **46**B, FIG. **46**C, FIG. **46**D, and FIG. **46**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 39;

FIG. 47A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 47B, FIG. 47C, FIG. 47D, and FIG. 47E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 40;

FIG. **48**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **48**B, FIG. **48**C, FIG. **48**D, and FIG. **48**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 41;

FIG. **49**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **49**B, FIG. **49**C, FIG. **49**D, and FIG. **49**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **42**;

FIG. **50**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **50**B, FIG. **50**C, FIG. **50**D, and FIG. **50**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 20 the optical system according to an example 43;

FIG. **51**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **51**B, FIG. **51**C, FIG. **51**D, and FIG. **51**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 25 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 44;

FIG. **52**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **52**B, FIG. **52**C, FIG. **52**D, and FIG. **52**E are diagrams showing a spherical 30 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 45;

FIG. **53**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **53**B, FIG. **53**C, 35 FIG. **53**D, and FIG. **53**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 46;

FIG. **54**A is a cross-sectional view along an optical axis 40 showing an optical arrangement, and FIG. **54**B, FIG. **54**C, FIG. **54**D, and FIG. **54**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 47;

FIG. **55**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **55**B, FIG. **55**C, FIG. **55**D, and FIG. **55**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 50 the optical system according to an example 48;

FIG. **56**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **56**B, FIG. **56**C, FIG. **56**D, and FIG. **56**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 55 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 49;

FIG. **57**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **57**B, FIG. **57**C, FIG. **57**D, and FIG. **57**E are diagrams showing a spherical 60 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **50**;

FIG. **58**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **58**B, FIG. **58**C, 65 FIG. **58**D, and FIG. **58**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

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a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 51;

FIG. **59**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **59**B, FIG. **59**C, FIG. **59**D, and FIG. **59**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **52**;

FIG. **60**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **60**B, FIG. **60**C, FIG. **60**D, and FIG. **60**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **53**;

FIG. **61**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **61**B, FIG. **61**C, FIG. **61**D, and FIG. **61**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **54**;

FIG. **62**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **62**B, FIG. **62**C, FIG. **62**D, and FIG. **62**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 55;

FIG. 63A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 63B, FIG. 63C, FIG. 63D, and FIG. 63E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 56;

FIG. **64**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **64**B, FIG. **64**C, FIG. **64**D, and FIG. **64**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 57;

FIG. **65**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **65**B, FIG. **65**C, FIG. **65**D, and FIG. **65**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **58**;

FIG. **66**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **66**B, FIG. **66**C, FIG. **66**D, and FIG. **66**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 59;

FIG. **67**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **67**B, FIG. **67**C, FIG. **67**D, and FIG. **67**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 60;

FIG. **68**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **68**B, FIG. **68**C, FIG. **68**D, and FIG. **68**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 61;

FIG. **69**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **69**B, FIG. **69**C, FIG. **69**D, and FIG. **69**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 62;

FIG. **70**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **70**B, FIG. **70**C, FIG. **70**D, and FIG. **70**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 63;

FIG. 71A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 71B, FIG. 71C, FIG. 71D, and FIG. 71E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 64;

FIG. **72**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **72**B, FIG. **72**C, FIG. **72**D, and FIG. **72**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 20 the optical system according to an example 65;

FIG. 73A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 73B, FIG. 73C, FIG. 73D, and FIG. 73E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 25 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 66;

FIG. 74A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 74B, FIG. 74C, FIG. 74D, and FIG. 74E are diagrams showing a spherical 30 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 67;

FIG. 75A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 75B, FIG. 75C, 35 FIG. 75D, and FIG. 75E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 68;

FIG. **76**A is a cross-sectional view along an optical axis 40 showing an optical arrangement, and FIG. **76**B, FIG. **76**C, FIG. **76**D, and FIG. **76**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 69;

FIG. 77A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 77B, FIG. 77C, FIG. 77D, and FIG. 77E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 50 the optical system according to an example 70;

FIG. **78**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **78**B, FIG. **78**C, FIG. **78**D, and FIG. **78**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 55 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 71;

FIG. **79**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **79**B, FIG. **79**C, FIG. **79**D, and FIG. **79**E are diagrams showing a spherical 60 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example **72**;

FIG. **80**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **80**B, FIG. **80**C, 65 FIG. **80**D, and FIG. **80**e are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

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a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 73;

FIG. **81**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **81**B, FIG. **81**C, FIG. **81**D, and FIG. **81**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 74;

FIG. **82**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **82**B, FIG. **82**C, FIG. **82**D, and FIG. **82**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 75;

FIG. **83**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **83**B, FIG. **83**C, FIG. **83**D, and FIG. **83**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 76;

FIG. **84**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **84**B, FIG. **84**C, FIG. **84**D, and FIG. **84**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 77;

FIG. **85**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **85**B, FIG. **85**C, FIG. **85**D, and FIG. **85**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 78;

FIG. **86**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **86**B, FIG. **86**C, FIG. **86**D, and FIG. **86**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 79;

FIG. **87**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **87**B, FIG. **87**C, FIG. **87**D, and FIG. **87**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 80;

FIG. **88**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **88**B, FIG. **88**C, FIG. **88**D, and FIG. **88**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 81;

FIG. **89**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **89**B, FIG. **89**C, FIG. **89**D, and FIG. **89**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 82;

FIG. 90A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 90B, FIG. 90C, FIG. 90D, and FIG. 90E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 83;

FIG. 91A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 91B, FIG. 91C, FIG. 91D, and FIG. 91E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 84;

FIG. 92A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 92B, FIG. 92C, FIG. 92D, and FIG. 92E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 85;

FIG. 93A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 93B, FIG. 93C, FIG. 93D, and FIG. 93E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 86;

FIG. **94**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **94**B, FIG. **94**C, FIG. **94**D, and FIG. **94**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 20 the optical system according to an example 87;

FIG. **95**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **95**B, FIG. **95**C, FIG. **95**D, and FIG. **95**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and 25 a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 88;

FIG. **96**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **96**B, FIG. **96**C, FIG. **96**D, and FIG. **96**E are diagrams showing a spherical 30 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 89;

FIG. **97**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **97**B, FIG. **97**C, 35 FIG. **97**D, and FIG. **97**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 90;

FIG. **98**A is a cross-sectional view along an optical axis 40 showing an optical arrangement, and FIG. **98**B, FIG. **98**C, FIG. **98**D, and FIG. **98**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 91;

FIG. **99**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **99**B, FIG. **99**C, FIG. **99**D, and FIG. **99**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of 50 the optical system according to an example 92;

FIG. **100**A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. **100**B, FIG. **100**C, FIG. **100**D, and FIG. **100**E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 93;

However, an optical system may be equipped with a focusing function.

An optical system according to a first embodiment will be described below. The optical system according to the first embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens

FIG. 101A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 101B, FIG. 101C, FIG. 101D, and FIG. 101E are diagrams showing a spherical 60 aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 94;

FIG. 102Å is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 102B, FIG. 102C, 65 FIG. 102D, and FIG. 102E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and

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a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 95;

FIG. 103A is a cross-sectional view along an optical axis showing an optical arrangement, and FIG. 103B, FIG. 103C, FIG. 103D, and FIG. 103E are diagrams showing a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC) respectively, of the optical system according to an example 96;

FIG. **104** is a diagram showing an arrangement of a microscope which is an optical instrument;

FIG. 105 is a diagram showing an arrangement of another microscope which is an optical instrument;

FIG. **106** is a diagram showing an arrangement of still another microscope which is an optical instrument; and

FIG. 107A is a diagram showing an arrangement of still another microscope which is an optical instrument, and FIG. 107B is a diagram showing a state that the microscope is fixed.

DETAILED DESCRIPTION OF THE INVENTION

Prior to description of examples, an action and effect of embodiments according to certain aspects of the present embodiment will be described below. At the time of describing concretely the action and effect of the present embodiment, the description will be made by citing specific examples. However, similar to cases of examples that will be described later, aspects to be exemplified are only some of the aspects included in the embodiment, and there are a large number of variations in those aspects. Consequently, the present invention is not restricted to aspects that will be exemplified.

For instance, in optical systems from an optical system according to a first embodiment up to an optical system according to a seventh embodiment, by imparting a function of an objective lens to a lens unit Gf, and by imparting a function of an image forming lens to a lens unit Gr, it is possible to form an optical system of a microscope as an optical instrument. An embodiment of the microscope will be described later.

In the following description, a 'sample image' is let to be an 'image' appropriately, and a 'sample' is let to be an 'object' appropriately.

Moreover, in the following description, a variable (such as, a focal length, an imaging magnification, and a numerical aperture) of which, a value changes with a wavelength, is with reference to a d-line unless specifically noted. Moreover, β is used for a magnification of an overall optical system, but β has been described as a projection magnification or an imaging magnification. Furthermore, optical systems of the following embodiments are optical systems with a fixed focal length. However, an optical system may be equipped with a focusing function.

An optical system according to a first embodiment will be described below. The optical system according to the first embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and one lens in the pair of lenses is included in the lens unit Gf, and the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OB}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OBr} / r_{TLf} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

where

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OBr} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 \mathbf{r}_{TLr} denotes a paraxial radius of curvature of an image-side surface of the other lens in the pair of lenses,

 $d_{O\!B}$ denotes a thickness on the optical axis of the one lens $\,$ 10 in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

The optical system according to the first embodiment includes the lens unit Gf having a positive refractive power, 15 the stop (aperture stop), and the lens unit Gr having a positive refractive power. Moreover, the lens unit Gf is disposed on the object side and the lens unit Gr is disposed on an image side, sandwiching the stop. Furthermore, the optical system has at least one pair of lenses that satisfies conditional expressions 20 (1), (2), and (3).

By at least one pair of lenses satisfying conditional expressions (1), (2), and (3), each of the lens unit Gf and the lens unit Gr has at least one lens of which, a shape is plane-symmetrical with respect to the stop. In other words, in the optical system 25 according to the first embodiment, there is at least one pair of lenses of which, the shape is plane-symmetrical with respect to the stop. Therefore, the optical system has symmetry with respect to the shape of the lens. Accordingly, it is possible to correct favorably, a chromatic aberration of magnification, a 30 distortion, and a coma. Here, the symmetry does not refer only to cases of being completely symmetrical, but also includes cases of being nearly symmetrical.

Moreover, when the numerical aperture on the image side of the optical system is made large, an occurrence of an 35 off-axis aberration is susceptible to be noticeable. However, according to the optical system of the first embodiment, even when the numerical aperture on the image side of the optical system is made large, it becomes easy to suppress the occurrence of the off-axis aberration. As a result, various aberrations are corrected favorably, and a bright and sharp sample image is formed.

An optical system according to a second embodiment will be described below. In the optical system according to the second embodiment, the following conditional expressions 45 (4) and (5) are satisfied:

$$0.1 \le NA, 0.1 \le NA'$$
 (4)

$$-2 < \beta < -0.5$$
 (5)

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system, and

β denotes a projection magnification of the optical system.

By satisfying conditional expressions (4) and (5), it is possible to form a bright and sharp image. Therefore, even if a light intensity of illuminating light or excitation light is small, a bright and sharp image is formed. Moreover, it is 60 possible to make the magnification (projection magnification) of the optical system one time, or close to one time. In this case, by making the numerical aperture on the object side large, it is possible to make the numerical aperture on the image side large (the purpose is served without making the 65 numerical aperture on the image side that small). As a result, it is possible to make the numerical aperture on the image side

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large while maintaining the optical system to be small-sized. Moreover, it is possible to correct various aberrations favorably

For making the numerical aperture on the image side large, it is necessary to make the numerical aperture on the object side large. However, by making so as to exceed a lower limit value of conditional expression (4), the numerical aperture on the object side is not required to be made large. Therefore, small-sizing of the optical system becomes easy. By making so as to exceed a lower limit of conditional expression (5), the magnification of the optical system does not become excessively large. In this case, various aberrations occurred in the lens unit Gf, such as the spherical aberration and a curvature of field, are not enlarged significantly in the lens unit Gr. Therefore, it is preferable from a viewpoint of correcting the aberration favorably to exceed the lower limit value of conditional expression (5).

By making so as to fall below an upper limit value of conditional expression (5), an image that is formed does not become excessively small. Therefore, observation and image pickup of a microstructure of a sample become easy.

Here, it is preferable that the following conditional expression (4') is satisfied instead of conditional expression (4).

Also, it is preferable that the following conditional expression (5') is satisfied instead of conditional expression (5).

$$-1.5 < \beta < -0.75$$
 (5')

Moreover, it is more preferable that the following conditional expression (5") is satisfied instead of conditional expression (5)

$$-1.2 < \beta < -0.8$$
 (5")

An optical system according to a third embodiment will be described below. The optical system according to the third embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (4) and (6) are satisfied:

$$0.1 \le NA, 0.1 \le NA'$$
 (4)

$$0.5 \le f_{OB} f_{TL} \le 2$$
 (6)

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

 \mathbf{f}_{OB} denotes a focal length of the lens unit Gf, and

 f_{TL} denotes a focal length of the lens unit Gr.

The optical system according to the third embodiment includes the lens unit Gf having a positive refractive power, the stop (aperture stop), and the lens unit Gr having a positive refractive power. Moreover, the lens unit Gf is disposed on the object side and the lens unit Gr is disposed on the image side, sandwiching the stop. Therefore, in the optical system according to the third embodiment, the refractive power is symmetrical with respect to the stop. In other words, regarding the refractive power, the optical system has symmetry.

Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the coma aberration favorably.

Moreover, when the numerical aperture on the image side of the optical system is made large, an occurrence of an off-axis aberration is susceptible to be noticeable. However, according to the optical system of the third embodiment, even when the numerical aperture on the image side of the optical

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system is made large, it becomes easy to suppress the occurrence of the off-axis aberration. As a result, various aberrations are corrected favorably, and a bright and sharp sample image is formed.

A technical significance of conditional expression (4) is as 5 mentioned above. Moreover, a technical significance of conditional expression (6) is similar to the technical significance of conditional expression (5).

Here, it is preferable that the following conditional expression (6') is satisfied instead of conditional expression (6).

$$0.75 < f_{OB}/f_{TL} < 1.5$$
 (6')

Moreover, it is more preferable that the following conditional expression (6") is satisfied instead of conditional expression (6).

$$0.8 < f_{OB}/f_{TL} < 1.2$$
 (6")

An optical system according to a fourth embodiment will be described below. The optical system according to the fourth embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (7), (8), and (9) are satisfied:

$$30\% \leq MTF_{OB}$$
 (*)

$$30\% \leq MFT_{TL}$$
 (8)

$$0 < d_1/\Sigma d < 0.5$$
 (9)

where,

 MTF_{OB} denotes an MTF (Modulation Transfer Function) 30 on an axis in the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

 MTF_{TL} denotes an MTF on an axis in the lens unit Gr, and is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical 35

aperture on the object side of the optical system, and

fe' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident 40 from the stop side respectively,

 ${\rm d_1}$ denotes a distance on an optical axis from a surface positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr, and

 Σ d denotes a sum total of lens thickness on the optical axis of the overall optical system.

By satisfying conditional expressions (7) and (8), it becomes possible to impart a function equivalent to a function of the objective to the lens unit Gf, and to impart a function equivalent to a function of the tube lens to the lens unit Gr. Accordingly, the optical system becomes suitable for a microscope optical system and an optical system which is suitable for an object of forming a sharp sample image, similar to the microscope optical system. Conditional expression (7-1) or conditional expression (7-1') that will be described later may be satisfied instead of conditional expression (8-1') that will be described later may be satisfied instead of conditional expression (8-1') that will be described later may be satisfied instead of conditional expression (8).

By satisfying conditional expression (9), it is possible to dispose the lens unit Gf and the lens unit Gr near the stop (pupil). Here, when the numerical aperture on the image side of the optical system is made large, an occurrence of the off-axis aberration is susceptible to be noticeable. However, 65 according to the optical system of the fourth embodiment, even when the numerical aperture on the image side of the

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optical system is made large, it becomes easy to suppress the occurrence of the off-axis aberration, particularly the occurrence of the coma. As a result, various aberrations are corrected favorably, and a bright and sharp sample image is formed. Any of conditional expressions (9-1), (9-1"), (9-1"), and (9-1"") which will be described later may be satisfied instead of conditional expression (9).

An optical system according to a fifth embodiment will be described below. The optical system according to the fifth embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (7), (8), and (10) are satisfied:

$$30\% \leq MTF_{OB}$$
 (7)

$$30\% \leq MFT_{TL}$$
 (8)

$$0 < d_2 / \Sigma d < 4 \tag{10}$$

where

 MTF_{OB} denotes an MTF on an axis in the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

MTF_{TL} denotes an MTF on an axis in the lens unit Gr, and 25 is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF_{OB} and MTF_{TL} are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident from the stop side respectively,

d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr, and

 Σ d denotes a sum total of lens thickness on the optical axis of the overall optical system.

A technical significance of conditional expressions (7) and (8) is as already been explained. Conditional expression (7-1) or conditional expression (7-1') that will be described later may be satisfied instead of conditional expression (7). Moreover, conditional expression (8-1) or conditional expression (8-1') that will be described later may be satisfied instead of conditional expression (8).

By satisfying conditional expression (10), the rear principal point of the lens unit Gf and the front principal point of the lens unit Gr are positioned near the stop (pupil). Here, when the numerical aperture on the image side of the optical system is made large, an occurrence of the off-axis aberration is susceptible to be noticeable. However, according to the optical system of the fifth embodiment, even when the numerical aperture on the image side of the optical system is made large, it becomes easy to suppress the occurrence of the off-axis aberration, particularly the occurrence of the coma. As a result, various aberrations are corrected favorably, and a bright and sharp image is formed. Any of conditional expressions (10-1), (10-1'), (10-1") and (10-1"') that will be described later may be satisfied instead of conditional expression (10).

It is preferable that the optical systems of embodiments from the first embodiment to the fifth embodiment (hereinafter, appropriately called as the optical system according to the present embodiment) have an arrangement of an optical system according to the other embodiments, and satisfy conditional expressions. Accordingly, it is possible to provide an optical system having a large numerical aperture on the image side, and in which, various aberrations are corrected favor-

ably. Moreover, a bright and sharp sample image, in which various aberrations are corrected favorably, is formed.

Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (11) is satisfied:

$$0.05 < \Delta f/Y < 0.05$$
 (11)

where,

 Δf denotes a difference in a focal position on a C-line and a focal position on an F-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side, and

Y denotes the maximum image height in an overall optical system.

In the optical system according to the present embodiment, 15 the optical system has symmetry with regard to a shape of lens or a refractive power of lens, or both. Therefore, the chromatic aberration of magnification, the distortion, and the coma occur in opposite directions in the lens unit Gf and the lens unit Gr. Therefore, by rendering the lens unit Gf and the lens 20 unit Gr in a combined state, it is possible to cancel an aberration occurred in the lens unit Gf, in the lens unit Gr.

However, a longitudinal chromatic aberration occurs in the same direction in both the lens unit Gf and the lens unit Gr. For this reason, in the state of the lens unit Gf and the lens unit 25 optical system, Gr combined, the aberration occurred in the lens unit Gf cannot be cancelled in the lens unit Gr. Therefore, the longitudinal chromatic aberration is required to be corrected only in the lens unit Gr. The longitudinal chromatic aberration is also required to be corrected only in the lens unit Gf.

By making so as to fall below an upper limit value of conditional expression (11) or by making so as to exceed a lower limit value of conditional expression (11), correction of the longitudinal chromatic aberration in the overall optical system becomes easy.

Moreover, it is preferable that the optical system according to the present embodiment has at least two pairs of lenses.

Regarding the shape of lens, symmetry of the optical system improves further. Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the 40 coma even more favorably.

Moreover, it is preferable that the optical system according to the present embodiment has at least three pairs of lenses.

Regarding the shape of lens, the symmetry of the optical system improves further. Therefore, it is possible to correct 45 the chromatic aberration of magnification, the distortion, and the coma favorably.

Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (12) is satisfied:

$$-10^{\circ} < \theta_{o} < 10^{\circ} \tag{12}$$

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object 55

By making so as to exceed a lower limit value of conditional expression (12), or by making so as to fall below an upper limit value of conditional expression (12), it is possible to impart telecentricity on the object side, in the optical sys- 60 tem. Accordingly, it is possible to suppress the fluctuation in magnification corresponding to a fluctuation in an object (photographic subject) distance. For instance, in a case of carrying out dimensional measurement by using the optical system according to the present embodiment, even when the 65 object (substance to be tested) has concavity and convexity in the optical axial direction, since a magnification for a concave

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portion and a magnification for a convex portion being same, an accurate measurement is possible.

In the optical system according to the present embodiment, it is preferable that each lens in the pair of lenses disposed at 5 a position nearest from the stop is a positive lens. Moreover, it is preferable that each lens in the pair of lenses disposed at a position second nearest from the stop is a negative lens.

An optical system according to a sixth embodiment will be described below. The optical system according to the sixth embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (9-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_1 / \Sigma d < 0.2 \tag{9-1}$$

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where.

NA denotes a numerical aperture on the object side of the

NA' denotes a numerical aperture on an image side of the optical system,

 β denotes a projection magnification of the optical system,

d₁ denotes a distance on an optical axis from a surface 30 positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit Gr,

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

€d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

An upper limit of a resolution on the object side is determined by the NA, and an upper limit of a resolving power on the image side is determined by the NA' and a pixel pitch of an image pickup element. By including in order from the object side, the lens unit Gf having a positive refractive power, the stop, and the lens unit Gr having a positive refractive power, as well as conditional expression (4-1) and (5) are satisfied simultaneously, it is possible to make a balance of the resolution on the object side and the resolving power on the image side favorable. Moreover, it is possible to correct various aberrations favorably, and to improve an imaging performance to the maximum limit, as well as to form an optical system of a small size. Particularly, the optical system according to the sixth embodiment is an optical system ideal for an image pickup element with the pixel pitch from about one time to three times of a visual light wavelength.

Moreover, by satisfying conditional expressions (4-1) and (5) simultaneously, even when the light intensity of the illuminating light and the excitation light is small, it is possible to form a bright and sharp image while maintaining the optical system to be small-sized.

For making the numerical aperture on the image side large, it is necessary to make the numerical aperture on the object side large. However, by making so as to exceed a lower limit value of conditional expression (5), the numerical aperture on the object side is not required to be made large. Therefore,

small-sizing of the optical system becomes easy. Moreover, by making so as to exceed the lower limit value of conditional expression (5), the magnification of the optical system does not become excessively large. In this case, various aberrations occurred in the lens unit Gf, such as the spherical aberration and the curvature of field, are not enlarged significantly in the lens unit Gr. Therefore, it is preferable from a viewpoint of correcting the aberration favorably to exceed the lower limit value of conditional expression (5).

By making so as to fall below an upper limit value of 10 conditional expression (5), an image that is formed does not become excessively small. Therefore, observation and image pickup of a microstructure of a sample become easy.

Here, it is preferable that the following conditional expression (4-1') is satisfied instead of conditional expression (4-1). 15

Moreover, it is preferable that the abovementioned conditional expression (4') is satisfied instead of conditional expression (4-1).

It is preferable that the abovementioned conditional expression (5') is satisfied instead of conditional expression (5). Moreover, it is more preferable that the abovementioned conditional expression (5") is satisfied instead of conditional expression (5).

By satisfying conditional expressions (9-1) and (13), regarding a lens arrangement in the lens unit Gf and a lens arrangement in the lens unit Gr, it is possible to dispose the lens unit Gf and the lens unit Gr near the stop while imparting symmetry with respect to the stop. When the numerical aperture on the image side of the optical system is made large, the occurrence of the off-axis aberration, particularly the occurrence of the coma becomes noticeable, but by making such an arrangement, it becomes easier to suppress the occurrence of such aberration. Here, \mathbf{d}_1 is a distance between the two surfaces, and the two surfaces in this case are both lens surfaces.

Here, it is preferable that the following conditional expression (9-1') is satisfied instead of conditional expression (9-1).

$$0 < d_1/\Sigma d < 0.15$$
 (9-1')

Moreover, it is more preferable that the following conditional expression (9-1") is satisfied instead of conditional expression (9-1).

$$0 < d_1/\Sigma d < 0.07$$
 (9-1")

Furthermore, it is even more preferable that the following conditional expression (9-1") is satisfied instead of conditional expression (9-1).

$$0 < d_1/\Sigma d < 0.03$$
 (9-1''')

By satisfying conditional expression (13), it is possible to correct the off-axis aberrations such as the chromatic aberration and the coma favorably while maintaining the correction of the longitudinal chromatic aberration to a favorable state. In the optical system according to the sixth embodiment, by satisfying conditional expressions (4-1) and (5), it becomes possible to make the numerical aperture on the image side large with respect to the numerical aperture on the object side, or to make an arrangement such that the numerical aperture on the image side does not become excessively small with respect to the numerical aperture on the object side. Accordingly, it is made possible to form a brighter and sharper image, but at the same time, it is necessary to suppress the occurrence of the longitudinal chromatic aberration of the overall optical system to be small.

The optical system according to the sixth embodiment includes in order from the object side, the lens unit Gf having

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a positive refractive power, the stop, and the lens unit Gr having a positive refractive power, and is an optical system which satisfies conditional expression (5), or in other words, an optical system with an imaging magnification to be one time or close to one time. In such optical system, by making so as to fall below an upper limit value of conditional expression (13) or by making so as to exceed a lower limit value of conditional expression (13), it is possible to suppress the occurrence of the longitudinal chromatic aberration in the lens unit Gr. By enabling to suppress the occurrence of the longitudinal chromatic aberration in the lens unit Gr, it is possible to make the excessive correction of the longitudinal chromatic aberration in the lens unit Gf unnecessary. Therefore, regarding a lens arrangement in the lens unit Gf and a lens arrangement in the lens unit Gr, it is possible to impart symmetry with respect to the stop. By making the numerical aperture of the optical system large, the occurrence of aberrations such as the coma and the chromatic aberration of magnification becomes noticeable, but since the lens arrange-20 ment in the lens unit Gf and the lens arrangement in the lens unit Gr have symmetry with respect to the stop, it becomes possible to correct these aberrations favorably. Here, the symmetry does not refer only to cases of being completely symmetrical, but also includes cases of being nearly symmetrical.

Here, it is preferable that the following conditional expression (13') is satisfied instead of conditional expression (13).

$$-15 < \Delta f_{cd} / \epsilon d < 15 \tag{13}$$

Moreover, it is more preferable that the following condi-30 tional expression (13") is satisfied instead of conditional expression (13).

$$-12 < \Delta f_{cd} / \epsilon d < 12 \tag{13''}$$

arrangement, it becomes easier to suppress the occurrence of such aberration. Here, d_1 is a distance between the two surfaces, and the two surfaces in this case are both lens surfaces.

Furthermore, it is even more preferable that the following conditional expression (13") is satisfied instead of conditional expression (13).

$$-7 < \Delta f_{cd} < d < 7 \tag{13}$$

An optical system according to a seventh embodiment will be described below. The optical system according to the seventh embodiment comprises in order from an object side, a lens unit Gf having a positive refractive power, a stop, and a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (10-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_2 / \Sigma d < 2 \tag{10-1}$$

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

β denotes a projection magnification of the optical system, d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr.

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

ed denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

A technical significance of conditional expressions (4-1), 5 (5), and (13) is as already been described above.

Moreover, by satisfying conditional expressions (10-1) and (13), regarding a lens arrangement in the lens unit Gf and a lens arrangement in the lens unit Gr, it is possible to position a principal point of the lens unit Gf and a principal point of the lens unit Gr near the stop while imparting symmetry with respect to the stop. When the numerical aperture on the image side of the optical system is made large, the occurrence of the off-axis aberration, particularly the occurrence of the coma becomes noticeable, but by making such an arrangement, it 15 becomes easier to suppress the occurrence of the aberration.

Here, it is preferable that the following conditional expression (10-1') is satisfied instead of conditional expression (10-1).

$$0 < d_2/\Sigma d < 1.5$$
 (10-1')

Moreover, it is more preferable that the following conditional expression (10-1") is satisfied instead of conditional expression (10-1).

$$0 < d_2/\Sigma d < 1$$
 (10-1") 25

Furthermore, it is even more preferable that the following conditional expression (10-1") is satisfied instead of conditional expression (10-1).

$$0 < d_2/\Sigma d < 0.7$$
 (10-1''') 30

It is all the more preferable to satisfy the following conditional expression (10-1"") instead of conditional expression (10-1)

$$0 < d_2 / \Sigma d < 0.4$$
 (10-1"") 35

It is preferable that the optical system according to the sixth embodiment and the optical system according to the seventh embodiment (hereinafter, called appropriately as an 'optical system according to the present embodiment') have an arrangement of an optical system according to the other embodiments, and satisfy conditional expressions. Accordingly, it is possible to provide an optical system with a large numerical aperture on the image side, and in which, various aberrations are corrected favorably. Moreover, a bright and sharp sample image, in which various aberrations are corrected favorably, is formed.

In the optical system according to the present embodiment, it is preferable that the following conditional expressions (7-1) and (8-1) are satisfied:

$$40\%$$
≤MTF_{OB} (7-1)

$$40\%{\leq}MTF_{TL} \tag{8-1}$$

where,

 MTF_{OB} denotes an MTF on an axis in the lens unit Gf, and 55 is an MTF with respect to a spatial frequency of fc/4,

MTF_{TL} denotes an MTF on an axis in the lens unit Gr, and is an MTF with respect to a spatial frequency of fc'/4, where fc denotes a cut-off frequency with respect to the numerical

fc denotes a cut-off frequency with respect to the numerical aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident from the stop side, respectively.

By satisfying conditional expressions (7-1) and (8-1), it becomes possible to impart a function equivalent to a function

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of the objective to the lens unit Gf, and to impart a function equivalent to a function of the tube lens to the lens unit Gr. Accordingly, in an optical arrangement in which, light emerged from the lens unit Gf becomes a substantially parallel light beam, it is possible to correct a longitudinal aberration favorably. Therefore, in the optical system which satisfies conditional expression (5), by further satisfying conditional expressions (7-1) and (8-1), regarding the arrangement of the lens unit Gf and the arrangement of the lens unit Gr, it becomes easy to impart symmetry with respect to the stop. As a result, it is possible to suppress an off-axis distortion, the chromatic aberration of magnification, and the coma favorably.

Furthermore, since a light beam passing through the stop becomes substantially parallel, it becomes possible to insert an optical element such as a phase plate and a polarization plate being necessary for various observation techniques (such as phase-contrast microscopy, polarization microscopy, and differential interference contrast microscopy), near the

Here, it is preferable that the following conditional expression (7-1') is satisfied instead of conditional expression (7-1).

$$50\% \leq MTF_{OB} \tag{7-1'}$$

Moreover, it is preferable that the following conditional expression (8-1') is satisfied instead of conditional expression (8-1).

$$50\% \leq MTF_{TL}$$
 (8-1')

In the optical system according to the present embodiment, it is preferable that the following conditional expression (6) is satisfied:

$$0.5 < f_{OB}/f_{TL} < 2$$
 (6)

where

 f_{OB} denotes a focal length of the lens unit Gf, and f_{TL} denotes a focal length of the lens unit Gr.

The optical system according to the present embodiment is an optical system which satisfies conditional expression (5), or in other words, is an optical system having a projection magnification which is one time or close to one time. In the optical system having a projection magnification which is one time or close to one time, by satisfying conditional expression (6), regarding an arrangement of the lens unit Gf and an arrangement of the lens unit Gr, it becomes possible to impart symmetry with respect to the stop. When the numerical aperture on the image side of the optical system is made large, the occurrence of off-axis aberrations such as the chromatic aberration of magnification and the coma becomes noticeable. However, since the arrangement of the lens unit Gf and the arrangement of the lens unit Gr have symmetry with respect to the stop, it becomes possible to correct these aberrations favorably.

It is preferable that the aforementioned conditional expression (6') is satisfied instead of conditional expression (6). Moreover, it is more preferable that the aforementioned conditional expression (6") is satisfied instead of conditional expression (6).

In the optical system according to the present embodiment, it is preferable that the following conditional expression (14) is satisfied:

$$0.78 < d_{SHOB}/d_{SHTL} < 1.3$$
 (14)

where,

 ${\rm d}_{SHOB}$ denotes a distance on the optical axis from a front principal point of the lens unit Gf up to the stop, and

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 d_{SHTL} denotes a distance on the optical axis from the stop up to a rear principal point of the lens unit Gr.

A technical significance of conditional expression (14) is same as the technical significance of conditional expression

It is preferable that the following conditional expression (14') is satisfied instead of conditional expression (14).

$$0.8 < d_{SHOB}/d_{SHTL} < 1.2$$
 (14')

It is more preferable that the following conditional expression (14") is satisfied instead of conditional expression (14).

$$0.9 < d_{SHOB}/d_{SHTL} < 1.1$$
 (14")

Moreover, in the optical system according to the present 15 embodiment, it is preferable that a positive lens Lf1 is disposed nearest to the image in the lens unit Gf.

By making such an arrangement, since it becomes possible to position a principal point of the lens unit Gf at the stop side conjugate length (distance from the object up to the image). Moreover, when the numerical aperture on the image side of the optical system is made large, the occurrence of the offaxis aberration, particularly the occurrence of the coma becomes noticeable. However, by positioning the principal 25 point of the lens unit Gf near the stop (pupil), it becomes easier to suppress the occurrence of the off-axis aberration.

Moreover, in the optical system according to the present embodiment, it is preferable that a positive lens Lr1 is disposed nearest to the object in the lens unit Gr.

By making such an arrangement, since it becomes possible to position a principal point of the lens unit Gr at the stop side (or near the stop), it becomes advantageous for shortening the conjugate length. Moreover, when the numerical aperture on the image side of the optical system is made large, the occur- 35 rence of the off-axis aberration, particularly the occurrence of the coma becomes noticeable. However, by positioning the principal point of the lens unit Gr near the stop (pupil), it becomes easier to suppress the occurrence of the off-axis aberration.

Moreover, in the optical system according to the present embodiment, it is preferable that a negative lens Lf2 is disposed on the object side of the positive lens Lf1 such that, the negative lens Lf2 is adjacent to the positive lens Lf1.

By the negative lens Lf2, it is possible to correct favorably 45 a chromatic aberration occurring in the positive lens Lf1. Besides, since the negative lens Lf2 is disposed to be adjacent to the positive lens Lf1, it is possible to suppress the occurrence of the chromatic aberration of magnification in the lens unit Gf. As a result, it is possible to correct the chromatic 50 aberration of magnification of the overall optical system favorably.

In the optical system according to the present embodiment, it is preferable that a negative lens Lr2 is disposed on the image side of the positive lens Lr1 such that, the negative lens 55 Lr2 is adjacent to the positive lens Lr1.

By the negative lens Lr2, it is possible to correct favorably the chromatic aberration occurring in the positive lens Lr1. Besides, since the negative lens Lr2 is disposed to be adjacent to the positive lens Lr1, it is possible to suppress the occur- 60 rence of the chromatic aberration of magnification in the lens unit Gr. As a result, it is possible to correct the chromatic aberration of magnification of the overall optical system favorably.

Moreover, in the optical system according to the present 65 embodiment, it is preferable that an object-side surface of the negative lens Lf2 is concave toward the object side.

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By making such an arrangement, since it is possible to make large an angle of incidence of an off-axis light beam incident on the negative lens Lf2, it is possible to shorten the conjugate length of the optical system while maintaining a wide range of observation (an actual field of view).

Moreover, in the optical system according to the present embodiment, it is preferable that an image-side surface of the negative lens Lr2 is concave toward the image side.

By making such an arrangement, since it is possible to make large an angle of emergence of an off-axis light beam emerging from the negative lens Lr2, it is possible to shorten the conjugate length of the optical system while maintaining a wide observation range.

Moreover, in the optical system according to the present embodiment, it is preferable that the lens unit Gf includes a lens Lfe which is disposed nearest to the object, and a shape of at least one lens surface of the lens Lfe is a shape having an inflection point.

By letting the shape of the lens surface near the object side (or near the stop), it becomes advantageous for shortening a 20 to be a surface shape having the inflection point, and by letting a refractive power at a periphery to differ from a refractive power at a center, it becomes possible to reduce an angle of emergence of the off-axis light beam with respect to the object plane while maintaining a principal plane of the lens unit Gf at an optimum position. Moreover, since a position through which, the off-axis ray passes through a lens surface near the object becomes high, by providing the point of inflection to that surface, and letting the refractive power at the periphery to differ from the refractive power at the center, it is possible to correct favorably the off-axis aberration such as the curvature of field and an astigmatism.

> Moreover, in the optical system according to the present embodiment, it is preferable that the lens unit Gr includes a lens Lre which is disposed nearest to the image, and a shape of at least one lens surface of the lens Lre is a shape having an inflection point.

> By letting the shape of the lens surface near the image side to be a surface shape having the inflection point, and by letting a refractive power at a periphery to differ from a refractive power at a center, it becomes possible to reduce an angle of incidence of the off-axis light beam with respect to the image plane while maintaining a principal plane of the lens unit Gr at an optimum position. Moreover, since a position through which, the off-axis ray passes through a lens surface near the image becomes high, by providing the point of inflection to that surface, and letting the refractive power at the periphery to differ from the refractive power at the center, it is possible to correct favorably the off-axis aberration such as the curvature of field and the astigmatism.

> Moreover, in the optical system according to the present embodiment, it is preferable that the lens Lfe has a negative refractive power.

> By making such an arrangement, since it becomes possible to position the principal plane of the lens unit Gf at the stop side, it becomes advantageous for shortening the conjugate length. Moreover, by positioning the principal plane of the lens unit Gf near the stop (pupil), even when the numerical aperture on the image side of the optical system is made large, it is possible to suppress the occurrence of the off-axis aberration, particularly the occurrence of the coma.

> Moreover, in the optical system according to the present embodiment, it is preferable that the lens Lre has a negative refractive power.

By making such an arrangement, since it becomes possible to position the principal plane of the lens unit Gr at the stop side, it becomes advantageous for shortening the conjugate length. Moreover, by positioning the principal plane of the

lens unit Gr near the stop (pupil), even when the numerical aperture on the image side of the optical system is made large, it is possible to suppress the occurrence of the off-axis aberration, and particularly the occurrence of the coma.

Moreover, in the optical system according to the embodiment, it is preferable that the 1 optical system includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and one lens in the pair of lenses is included in the lens unit Gf, and the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OBf} / r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OBr} / r_{TLf} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

where.

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OB_P} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 r_{TLr} denotes a paraxial radius of curvature of an image-side 25 surface of the other lens in the pair of lenses,

 \mathbf{d}_{OB} denotes a thickness on the optical axis of the one lens in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

The technical significance of conditional expressions (1), (2), and (3) is as aforementioned.

Moreover, it is preferable that the optical system according to the present embodiment has at least two pairs of lenses.

Regarding the shape of lens, symmetry of the optical system improves further. Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the coma even more favorably.

Moreover, it is preferable that the optical system according to the present embodiment has at least three pairs of lenses.

Regarding the shape of lens, the symmetry of the optical system improves further. Therefore, it is possible to correct the chromatic aberration of magnification, the distortion, and the coma favorably.

Moreover, in the optical system according to the present $_{45}$ embodiment, it is preferable that the following conditional expression (12-1) is satisfied:

$$-10^{\circ} < \theta_{o} < 30^{\circ}$$
 (12-1)

where.

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object side.

By making so as to exceed a lower limit value of conditional expression (12-1), or making so as to fall below an 55 upper limit value of conditional expression (12-1), it is possible to impart telecentricity on the object side, in the optical system. Accordingly, it is possible to suppress the fluctuation in magnification corresponding to a fluctuation in the object (photographic subject) distance. For instance, in a case of 60 carrying out dimensional measurement by using the optical system of the present embodiment, even when the object (substance to be tested) has concavity and convexity in the optical axial direction, since it is possible to make a difference in a magnification for a concave portion and a magnification 65 for a convex portion small, an accurate measurement is possible.

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Moreover, in a case of seeking even higher telecentricity in the optical system, in the optical system according to the present embodiment, it is preferable that the following conditional expression (12-1') is satisfied.

$$-5^{\circ} < \theta_o < 5^{\circ} \tag{12-1'}$$

Moreover, in a case of seeking further small-sizing (short-ening overall length of the optical system, and making a diameter fine) in the optical system, in the zoom lens of the present embodiment, it is preferable that the following conditional expression (12-1") is satisfied.

$$15^{\circ} < \theta_{a} < 30^{\circ}$$
 (12-1")

A focal length of a tube lens used in a conventional microscope is approximately 10 times of a focal length of a microscope objective. Therefore, the numerical aperture (NA') on the image side becomes small to about 0.08. However, in the aforementioned embodiments from the first embodiment to the seventh embodiment, it is possible to realize an optical system in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably.

Moreover, an optical instrument (such as a microscope) of the present embodiment includes the aforementioned optical system, and an image pickup element.

According to the optical instrument of the present embodiment, it is possible to realize an optical instrument in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably. Moreover, a bright and sharp sample image in which, various aberrations have been corrected, is formed.

An optical system according to an eighth embodiment, an optical system according to a ninth embodiment, and an optical system according to a tenth embodiment (hereinafter, appropriately called as an 'optical system according to the present embodiment') will be described below. Moreover, a marginal ray is a light rays emerged from an object point on the optical axis, and passing through a peripheral portion of an entrance pupil of the optical system. Here, in the following description, in a case in which, the marginal ray has emerged from an object point on the optical axis, the marginal ray will be let to be an axial marginal ray, and in a case in which, the marginal ray has emerged from an off-axis object point, the marginal ray will be let to be an off-axis marginal ray. Moreover, the optical system according to the present embodiment is an optical system presupposing that an object is at a finite distance from the optical system (finite correction optical system).

Moreover, in an image pickup apparatus using the optical system according to the present embodiment, it is possible to let an image photographed to be subjected to digital zooming, and make a magnified display thereof. Therefore, the optical systems of these embodiments have a high resolution as various aberrations are corrected favorably, and are capable of forming an image over a wide observation range. In the optical systems of these embodiments, since a longitudinal chromatic aberration and an off-axis chromatic aberration in particular, has been corrected favorably, by combining with an image pickup element having a small pixel pitch, a magnified image with a high resolution is achieved even in a case in which, the image captured is magnified by digital zooming.

The optical system according to the eighth embodiment is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and comprises in order from an object side,

a first lens unit having a positive refractive power, which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens 10 which is disposed nearest to an image, and

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expressions (15), (16), (19), and 15 (20) are satisfied:

$$\beta \leq -1.1 \tag{15}$$

$$1.0 < WD/BF \tag{19}$$

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 4.0$$
 (20)

 β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the optical system,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens,

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image,

Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

The optical system according to the ninth embodiment is 35 an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and comprises in order 40 optical system, from an object side,

- a first lens unit which includes a plurality of lenses,
- a stop, and
- a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens 50 which is disposed nearest to an image, and

the following conditional expressions (16), (21), (23-1), and (24-1) are satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

$$0.6 \le L_I/D_{oi}$$
 (23-1)

$$0.015 < 1 / v d_{min} - 1 / v d_{max}$$
 (24-1)

NA denotes a numerical aperture on the object side of the optical system,

 D_{max} denotes a maximum distance from among distances 65 on an optical axis of adjacent lenses in the optical system,

 ϕ_s denotes a diameter of the stop,

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L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side surface of the second image-side lens,

 D_{oi} denotes a distance on the optical axis from the object to the image.

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system.

The optical system according to the tenth embodiment is an optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 µm, and comprises in order from an object side,

- a first lens unit which includes a plurality of lenses,
- a stop, and

a second lens unit which includes a plurality of lenses,

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (18), and (25) are satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C}))) / \Sigma_d < 30$$
(18)

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

NA denotes a numerical aperture on the object side of the

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G_1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object (16) 55 side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system,

D_{os} denotes a distance on the optical axis from the object up to the stop, and

D_{at} denotes a distance on the optical axis from the object up to the image, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

Each of the optical system according to the eighth embodiment, the optical system according to the ninth embodiment, and the optical system according to the tenth embodiment is an optical system that forms an optical image on the image pickup element. Here, the image pickup element includes a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively.

In the optical system according to the eighth embodiment, it is preferable that the following conditional expression (15) is satisfied:

$$\beta \leq -1.1$$
 (15)

where,

 β denotes an imaging magnification of the optical system. When the numerical aperture on the object side of the optical system is enlarged (the numerical aperture is made large), and a working distance is made long to a certain extent, since a height of an axial marginal ray incident on the optical system (lens positioned nearest to the object) becomes high, the axial aberration is susceptible to occur. Therefore, by satisfying conditional expression (15), since it is possible to suppress the height of the axial marginal ray and the off-axis marginal ray incident on the optical system, it is possible to suppress further the occurrence of the axial aberration and the off-axis aberration.

Moreover, in the optical system according to the ninth ³⁰ embodiment, it is preferable that the following conditional expression (15-1) is satisfied:

$$\beta \leq -1.0 \tag{15-1}$$

where,

β denotes an imaging magnification of the optical system. By satisfying conditional expression (15-1), the optical system becomes a magnifying optical system. Accordingly, it is possible to realize more detailed observation.

Moreover, in the optical system according to the tenth embodiment, it is preferable that the following conditional expression (15-2) is satisfied:

$$-1.1 \le \beta \le -0.9$$
 (15-2)

where.

 β denotes an imaging magnification of the optical system. Moreover, in the optical system according to the present embodiment, it is preferable that the following conditional expression (16) is satisfied:

where,

NA denotes a numerical aperture on the object side of the optical system.

By satisfying conditional expression (16), it is possible to realize an optical system and an image pickup apparatus having a high resolution.

Moreover, it is preferable that the optical system according to the present embodiment is an optical system which is used 60 in a microscope.

It is preferable that the optical system according to the present embodiment includes in order from an object side, a first lens unit which includes a plurality of lenses, a stop, and a second lens unit which includes a plurality of lenses, and that the lens units which form the optical system include the first lens unit and the second lens unit. It is preferable that the

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stop is an aperture stop. It is possible that the lens units which form the optical system consist of the first lens unit and the second lens unit.

Moreover, in the optical system according to the present embodiment, it is preferable that the first lens unit includes a first object-side lens which is disposed nearest to an object. Moreover, it is preferable that the first lens unit includes a first image-side lens which his disposed nearest to the image. It is preferable that the second lens unit includes a second object-side lens which is disposed nearest to the object. Moreover, it is preferable that the second lens unit includes a second image-side lens which is disposed nearest to the image.

In the optical system according to the present embodiment, it is preferable that the following conditional expression (17) is satisfied:

$$L_{TL}/2Y < 15$$
 (17)

where,

 ${\rm L}_{\it TL}$ denotes a distance on an optical axis from an object-side surface of the first object-side lens up to an image, and

Y denotes a maximum image height in an overall optical system.

By satisfying conditional expression (17), it is possible to make the optical system and the overall image pickup apparatus small.

Moreover, in the optical system according to the present embodiment, it is preferable that the lens units which form the optical system includes the first lens unit and the second lens unit, and the pitch of pixels is not more than 5.0 μ m, and the following conditional expression (18) is satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC})$$

$$f_{G2C})))/\epsilon_d < 30$$
(18)

where

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 $\Delta D_{G1,dC}$ denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit, and

 ϵ_d denotes an Airy disc radius for the d-line which is determined by the numerical aperture on the image side of the optical system, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

Conditional expression (18) is a conditional expression related to a balance between a correction function of the longitudinal chromatic aberration of the first lens unit and a correction function of the longitudinal chromatic aberration of the second lens unit, and is a conditional expression related to a difference in an image position on the d-line and an image position on the C-line. By the first lens unit and the second

lens unit satisfying conditional expression (18), it is possible to correct the longitudinal chromatic aberration of the overall optical system favorably. Moreover, by the longitudinal chromatic aberration being corrected favorably, it is possible to improve the resolution of the optical system. As a result, it is possible to observe a microscopic structure of a sample with a high resolution, even in color.

Particularly, in the optical system which satisfies conditional expressions (15-2) and (16), or in other words, in the optical system with a large numerical aperture on the image side, for achieving high resolution, it is necessary that the longitudinal chromatic aberration has been corrected more favorably, and by satisfying conditional expression (18), the abovementioned effect is achieved.

At the time of calculating ϵ_d , the optical system is assumed 15 to be an ideal optical system. When the optical system is assumed to be an ideal optical system, the shape of the Airy disc becomes circular. Since a size of the radius of the Airy disc is determined by the numerical aperture on the image side, it is possible to calculate the radius of the Airy disc 20 uniquely.

Moreover, it is preferable to let the pitch of the pixels to be not less than 0.5 $\mu m.$

Here, it is preferable that the following conditional expression (18') is satisfied instead of conditional expression (18). 25

$$-21 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC})$$

$$f_{G2C})))/\epsilon_d < 21$$
(18)

Moreover, it is more preferable that the following conditional expression (18") is satisfied instead of conditional expression (18).

negative lens, and (20) is satisfied:

$$-15 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{GC}))) / \epsilon_d < 15$$

$$(18")$$

Furthermore, it is even more preferable that the following conditional expression (18") is satisfied instead of conditional expression (18).

$$-9 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2)/(1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C})))/\epsilon_d < 9$$

$$(18"')$$

In the optical system according to the eighth embodiment 40 and the optical system according to the tenth embodiment, it is preferable that the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from an image-50 side surface of the second image-side lens up to an image.

It is preferable to dispose the lens unit having a positive refractive power on the object side of the stop. Accordingly, it is possible to position the principal point on the object side. Therefore, it is possible to shorten the overall length of the 55 optical system while maintaining the state in which, the longitudinal chromatic aberration has been corrected favorably.

In conditional expression (19), WD is the distance on the optical axis from the object up to the object-side surface of the first object-side lens, but will be called as a working distance 60 in the present specification. Moreover, BF is the distance on the optical axis from the image-side surface of the second image-side lens up to the image, but will be called as a back focus in the present specification. Accordingly, conditional expression (19) can be said to be a conditional expression 65 which regulates an appropriate ratio of the working distance and the back focus.

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By making so as not to fall below a lower limit value of conditional expression (19), it is possible to prevent the back focus from becoming excessively long. When such an arrangement is made, since it is possible to make a distance from the stop up to the image short, it is possible to make a height of a principal ray higher on the image side than at the stop. As a result, since it is possible to carry out an aberration correction in a state in which, the height of the principal ray has become high in the second lens unit, it is possible to correct favorably the chromatic aberration of magnification in particular.

Here, it is preferable that the following conditional expression (19') is satisfied instead of conditional expression (19).

$$1.2 < WD/BF < 50.0$$
 (19')

Moreover, it is more preferable that the following conditional expression (19") is satisfied instead of conditional expression (19).

Furthermore, it is even more preferable that the following conditional expression (19") is satisfied instead of conditional expression (19).

$$2.0 < WD/BF < 17.5$$
 (19")

In the optical system according to the eighth embodiment, it is preferable that the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and that the following conditional expression (20) is satisfied:

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 4.0$$
 (20)

where.

WD denotes a distance on an optical axis from the object up 35 to the object-side surface of the first object-side lens,

NA denotes a numerical aperture on the object side of the optical system,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

By disposing the positive lens and the negative lens in the first lens unit, it is possible to correct the longitudinal chromatic aberration favorably. At this time, by disposing the positive lens on the object side of the negative lens, it is possible to correct the longitudinal chromatic aberration 45 more favorably.

By satisfying conditional expression (20), it is possible to correct the chromatic aberration more favorably. The stop being the aperture stop, it is possible to let the stop to be a stop that determines the NA.

By making so as not to fall below a lower limit value of conditional expression (20), it is possible to suppress a predetermined refraction effect in the first lens unit from becoming excessively small. Therefore, since it is possible to position a principal point sufficiently on the object side, it is possible to shorten the overall length of the optical system. The predetermined refraction is an effect of making a light ray refract in order to bring closer to the optical axis. Larger the predetermined refraction effect, the light ray is refracted in a direction of coming closer to the optical axis. For instance, larger the predetermined refraction effect, convergence becomes stronger in the convergence effect, and divergence becomes weaker in the divergence effect.

By making so as not to exceed an upper limit value of conditional expression (20) is not exceeded, it is possible to prevent the predetermined refraction effect in the first lens unit from becoming excessively large. Accordingly, it is possible to correct the longitudinal chromatic aberration due to

the axial marginal ray and the off-axis chromatic aberration at the maximum image height favorably and in a balanced manner. Even in a range of satisfying conditional expression (16), it is possible to correct the longitudinal chromatic aberration and the off-axis chromatic aberration favorably and in a balanced manner.

By satisfying conditional expressions (16), (19), and (20), it is possible to realize enlargement of the numerical aperture on the object side, shortening of the overall length of the optical system, and favorable correction of the chromatic aberration, while securing appropriately a thickness of optical components forming the optical system.

Here, it is preferable that the following conditional expression (20') is satisfied instead of conditional expression (20).

$$0.63 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 3.70$$
 (20')

Moreover, it is more preferable that the following conditional expression (20") is satisfied instead of conditional expression (20).

$$0.78 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 3.50$$
 (20")

Furthermore, it is even more preferable that the following conditional expression (20") is satisfied instead of conditional expression (20).

$$0.98 < 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obi})/\phi_s < 3.15$$
 (20")

In the optical system according to the tenth embodiment, it is preferable that the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and the following conditional expression (20-1) is satisfied:

$$1.0 < 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj})/\phi_s < 5.0$$
 (20-1)

where,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens,

NA denotes a numerical aperture on the object side of the optical system,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (20-1), it is possible to realize simultaneously, enlargement of the numerical aperture on the object side, shortening of the overall length of the optical system, and favorable correction of the chromatic aberration, while securing appropriately a thickness of optical components forming the optical system.

A technical significance of conditional expression (20-1) is same as the technical significance of conditional expression (20).

BY satisfying conditional expressions (16) and (20-1), and conditional expression (25) that will be described later, it is possible to correct the chromatic aberration more favorably while securing the required lens thickness, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (20-1') is satisfied instead of conditional expression (20-1).

$$1.33 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 4.75$$
 (20-1')

Moreover, it is more preferable that the following conditional expression (20-1") is satisfied instead of conditional expression (20-1).

Furthermore, it is even more preferable that the following conditional expression (20-1") is satisfied instead of conditional expression (20-1).

$$2.37 < 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj})/\phi_s < 4.29$$
 (20-1"')

In the optical system according to the present embodiment, it is preferable that the following conditional expression (21) is satisfied:

$$0.01 < D_{max} / \phi_s < 3.0$$
 (21)

where

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 ${\rm D}_{max}$ denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (21), it is possible to correct a chromatic coma more favorably.

By making so as not to fall below a lower limit value of conditional expression (21), it is possible to reduce deterioration of aberration due to a manufacturing error. For instance, decentering of a lens at the time of lens assembling is an example of the manufacturing error.

By making so as not to exceed an upper limit value of conditional expression (21), even in a case in which, the numerical aperture on the object side is large, it is possible to suppress the height of the off-axis marginal ray with respect to the height of the axial marginal ray from changing substantially between the lenses. For instance, let two adjacent lenses be a lens L_A and a lens L_B . The height of the off-axis marginal ray for the lens L_A and the height of the off-axis marginal ray for the lens L_B differ. However, by making a distance between the lens L_A and the lens L_B appropriate, it is possible to reduce the difference between the height of the off-axis marginal ray for the lens L₄ and the height of the off-axis marginal ray for the lens L_B . As a result, since it is possible to reduce a difference between the chromatic aberration for an off-axis light beam incident on the lens L_A and the chromatic aberration for an off-axis light beam incident on the lens L_B , it is possible to suppress an occurrence of the chromatic coma.

By satisfying conditional expressions (20) and (21), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Moreover, by satisfying conditional expression (21), and conditional expressions (23-1) and (24-1) which will be described later, it is possible to correct the chromatic coma favorably while securing appropriately the thickness of the optical components forming the optical system, and besides, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (21), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Here, it is preferable that the following conditional expression (21') is satisfied instead of conditional expression (21).

$$0.01 < D_{max}/\phi_s < 2.85$$
 (21')

Moreover, it is more preferable that the following conditional expression (21") is satisfied instead of conditional expression (21).

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Furthermore, it is even more preferable that the following conditional expression (21") is satisfied instead of conditional expression (21).

$$0.03 \le D_{max}/\phi_s \le 2.0$$
 (21")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (22) is satisfied:

$$0.01 \le D_{G1max}/\phi_s \le 2.0$$
 (22)

where

 ${\rm D}_{G1max}$ denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens unit, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (22), it is possible to correct a chromatic coma more favorably.

By making so as not to fall below a lower limit value of conditional expression (22), it is possible to reduce deterioration of aberration due to a manufacturing error. For instance, decentering of a lens at the time of lens assembling is an example of the manufacturing error.

By making so as not to exceed an upper limit value of conditional expression (22), even in a case in which, the numerical aperture on the object side is large, it is possible to suppress the height of the off-axis marginal ray with respect to the height of the axial marginal ray from changing substantially between the lenses. For instance, let two adjacent lenses be a lens L_A and a lens L_B . The height of the off-axis marginal ray for the lens L_A and the height of the off-axis marginal ray for the lens L_B differ. However, by making a distance between the lens L_A and the lens L_B appropriate, it is possible to reduce the difference between the height of the off-axis marginal ray for the lens L₄ and the height of the off-axis marginal ray for the lens L_B . As a result, since it is possible to reduce a difference between the chromatic aberration for an off-axis light beam incident on the lens L_A and the chromatic aberration for an off-axis light beam incident on the lens L_B , it is possible to suppress an occurrence of the chromatic coma.

By satisfying conditional expressions (20) and (22), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Moreover, by satisfying conditional expression (22), and conditional expressions (23-1) and (24-1) which will be described later, it is possible to correct the chromatic coma favorably while securing appropriately the thickness of the optical components forming the optical system, and besides, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (22), it is possible to correct the chromatic coma more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, and while securing appropriately the thickness of the optical components forming the optical system.

Here, it is preferable that the following conditional expression (22') is satisfied instead of conditional expression (22).

$$0.01 \le D_{G1max}/\phi_s \le 1.80$$
 (22')

Moreover, it is more preferable that the following conditional expression (22") is satisfied instead of conditional expression (22).

$$0.02 \le D_{G1max}/\phi_s \le 1.62$$
 (22")

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Furthermore, it is even more preferable that the following conditional expression (22") is satisfied instead of conditional expression (22).

$$0.03 \le D_{G1max}/\phi_s < 1.46$$
 (22"')

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi} \tag{23}$$

where,

 L_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the image-side 15 surface of the second image-side lens, and

 D_{oi} denotes a distance on the optical axis from the object up to the image.

By making so as not to fall below a lower limit value of conditional expression (23), even in an optical system having the overall length shortened, since it becomes possible to change the height of the principal ray emerged from a periphery of the object and reaching a periphery of the image comparatively gradually, it is possible to prevent a radius of curvature (paraxial radius of curvature) of a lens in the optical system from becoming excessively small. As a result, it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification

Moreover, by satisfying conditional expressions (20) and (23), even in an optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably.

By satisfying conditional expression (23), and conditional expression (25) that will be described later, even in an optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably.

It is preferable that the following conditional expression (23') is satisfied instead of conditional expression (23).

$$0.42 < L_L/D_{oi} < 0.99$$
 (23')

Moreover, it is more preferable that the following conditional expression (23") is satisfied instead of conditional expression (23).

$$0.44 < L_L/D_{oi} < 0.98$$
 (23")

Furthermore, it is even more preferable that the following conditional expression (23") is satisfied instead of conditional expression (23).

$$0.47 < L_I/D_{oi} < 0.97$$
 (23"')

In the optical system according to the ninth embodiment, it is preferable that the following conditional expression (23-1) is satisfied:

$$0.6 \le L_I/D_{ci} \tag{23-1}$$

 ${\rm L}_L$ denotes a distance on the optical axis from an object-side surface of the first object-side lens up to an image-side surface of the second image-side lens, and

 D_{oi} denotes a distance on the optical axis from the object to an image.

A technical significance of conditional expression (23-1) is same as the technical significance of conditional expression (23)

By satisfying conditional expression (23-1), and conditional expression (24-1) that will be described later, it is possible to achieve both, the favorable correction of the chromatic aberration (longitudinal chromatic aberration and chromatic aberration of magnification) in particular, and shortensing of the overall length of the optical system.

Here, it is preferable that the following conditional expression (23-1') is satisfied instead of conditional expression (23-1).

$$0.63 < L_I/D_{ei} < 0.99$$
 (23-1')

Moreover, it is more preferable that the following conditional expression (23-1") is satisfied instead of conditional expression (23-1).

$$0.66 < L_L/D_{oi} < 0.98$$
 (23-1")

Furthermore, it is even more preferable that the following conditional expression (23-1") is satisfied instead of conditional expression (23-1).

$$0.70 < L_L/D_{oi} < 0.97$$
 (23-1"")

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (24) is satisfied:

$$0.01 < 1/v d_{min} - 1/v d_{max}$$
 (24)

where.

 vd_{min} denotes a smallest Abbe's number from among $_{30}$ Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the optical system.

By making so as not to fall below a lower limit value of conditional expression (24), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification favorably. In a case in which, the optical system includes a diffractive optical element, a lens which forms the diffractive optical element is to be excluded from the 'lenses forming the optical system' in conditional expression (24).

By satisfying conditional expressions (20) and (24), even in an optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration 45 and the chromatic aberration of magnification more favorably.

By satisfying conditional expression (24), and conditional expression (25) that will be described later, even in the optical system having the overall length shortened as well as the numerical aperture on the object side enlarged, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably.

Here, it is preferable that the following conditional expression (24') is satisfied instead of conditional expression (24). 55

$$0.012 < 1/v d_{min} - 1/v d_{max} < 0.050$$
 (24')

Moreover, it is more preferable that the following conditional expression (24") is satisfied instead of conditional expression (24).

$$0.014 < 1/v d_{min} - 1/v d_{max} < 0.040$$
 (24")

Furthermore, it is even more preferable that the following conditional expression (24") is satisfied instead of conditional expression (24).

$$0.016 < 1/v d_{min} - 1/v d_{max} < 0.035$$
 (24")

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In the optical system according to the ninth embodiment, it is preferable that the following conditional expression (24-1) is satisfied:

$$0.015 < 1/v d_{min} - 1/v d_{max}$$
 (24-1)

where,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and vd_{max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the optical system.

A technical significance of conditional expression (24-1) is same as the technical significance of conditional expression (24).

By satisfying conditional expressions (15-1), (16), and (24-1), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification favorably. As a result, it is possible to observe a microscopic structure of a sample with a high resolution, even in color.

Here, it is preferable that the following conditional expression (24-1') is satisfied instead of conditional expression (24-1).

$$0.017 < 1/\nu d_{min} - 1/\nu d_{max} < 0.050$$
 (24-1')

Moreover, it is more preferable that the following conditional expression (24-1") is satisfied instead of conditional expression (24-1).

$$0.019 < 1/v d_{min} - 1/v d_{max} < 0.040$$
 (24-1")

Furthermore, it is even more preferable that the following conditional expression (24-1") is satisfied instead of conditional expression (24-1).

$$0.021 < 1/v d_{min} - 1/v d_{max} < 0.035$$
 (24-1"")

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where

 D_{os} denotes a distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object up to the image.

By making so as not to fall below a lower limit value of conditional expression (25), it is possible to maintain appropriately the positive refractive power of the first lens unit while securing an appropriate thickness in lenses forming the first lens unit. As a result, it is possible to correct the chromatic aberration favorably while correcting a monochromatic aberration such as the curvature of field in the first lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the first lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the second lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By making so as not to exceed an upper limit value of conditional expression (25), since it becomes possible to change the height of the principal ray emerged from the stop and reaching a periphery of the image comparatively gradually, it is possible to prevent a radius of curvature of a lens in the second lens unit from becoming excessively small. Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration such as the curvature of field in the second lens unit.

By satisfying conditional expressions (16), (19), (20), and (25), it is possible to correct the chromatic aberration more favorably while suppressing an occurrence of the monochromatic aberration such as the curvature of field, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (25), it is possible to realize simultaneously, enlargement of the numerical aperture on the object side, shortening of the overall length of the optical system, and favorable correction of the chromatic aberration, while suppressing the occurrence of the monochromatic aberration such as the curvature of field.

Here, it is preferable to that following conditional expression (25') is satisfied instead of conditional expression (25). 15

$$0.19 < D_{os}/D_{oi} < 0.76$$
 (25)

Moreover, it is more preferable that the following conditional expression (25") is satisfied instead of conditional expression (25).

$$0.21 < D_{os}/D_{oi} < 0.72$$
 (25")

Furthermore, it is even more preferable that the following conditional expression (25") is satisfied instead of conditional expression (25).

$$0.35 < D_{os}/D_{oi} < 0.69$$
 (25")

In the optical system according to the ninth embodiment, it is preferable that the following conditional expression (25-1) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.65$$
 (25-1)

where.

 D_{os} denotes a distance on an optical axis from the object up $_{35}$ to the stop, and

 D_{oi} denotes a distance on the optical axis from the object up to an image.

A technical significance of conditional expression (25-1) is same as the technical significance of conditional expression $_{40}$ (25).

By satisfying conditional expressions (23-1), (24-1), and (25-1), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (25-1') is satisfied instead of conditional expression (25-1).

$$0.17 < D_{os}/D_{oi} < 0.62$$
 (25-1')

Moreover, it is more preferable that the following conditional expression (25-1") is satisfied instead of conditional expression (25-1).

$$0.21 < D_{os}/D_{oi} < 0.59$$
 (25-1")

Furthermore, it is even more preferable that the following conditional expression (25-1") is satisfied instead of conditional expression (25-1).

$$0.35 < D_{os}/D_{oi} < 0.56$$
 (25-1"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (26) is satisfied:

$$0.95 < \phi_{GL}/(2 \times Y/|\beta|) \tag{26}$$

where.

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system, and

 β denotes an imaging magnification of the optical system.

By making so as not to fall below a lower limit value of conditional expression (26), it is possible to make small a difference in angles of incidence when the off-axis marginal ray is incident on the lens, or in other words, to make small a difference in an angle of incidence of an upper-side light ray and an angle of incidence of a lower-side light ray. Accordingly, it is possible to correct the coma and the chromatic coma favorably. Moreover, in an optical system having the numerical aperture on the object side enlarged, it is possible to correct the coma and the chromatic coma favorably.

Here, it is preferable that the following conditional expression (26') is satisfied instead of conditional expression (26).

$$1.00 < \phi_{G1o}/(2 \times Y/|\beta|) < 10.00$$
 (26')

Moreover, it is more preferable that the following conditional expression (26") is satisfied instead of conditional expression (26).

$$1.05 < \phi_{GLo}/(2 \times Y/|\beta|) < 7.00$$
 (26")

Furthermore, it is even more preferable that the following conditional expression (26") is satisfied instead of conditional expression (26).

$$1.11 < \phi_{G1o}/(2 \times Y/|\beta|) < 5.00$$
 (26"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where.

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BF denotes a distance on an optical axis from the imageside surface of the second image-side lens up to the image, and

 \mathcal{L}_L denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens.

By making so as not to fall below a lower limit value of conditional expression (27), it is possible to increase a distance between the second image-side lens and the image pickup element. Accordingly, even when a ghost is generated due to multiple reflection between the second image-side lens and the image pickup element, it is possible to prevent the ghost from being incident on a surface of the image pickup element with a high density.

By making so as not to exceed an upper limit value of conditional expression (27), it is possible to prevent occupancy of a space of the back focus with respect to the overall length of the optical system from becoming excessively large. Accordingly, since there is an increase in a degree of freedom of positions at the time of disposing the lenses, it is possible to correct various aberrations favorably. For instance, by disposing a lens having a function of correcting chromatic aberration in the first lens unit and the second lens unit, and adjusting a positional relationship of these lenses, it is possible to achieve both, the favorable correction of the longitudinal chromatic aberration and the favorable correction of the chromatic aberration of magnification.

By satisfying conditional expressions (16), (19), (20), and (27), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more

favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (23-1), (24-1), and (27), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (27), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (27') is satisfied instead of conditional expression (27).

$$0.01 < BF/L_L < 0.36$$
 (27')

Moreover, it is more preferable that the following conditional expression (27") is satisfied instead of conditional expression (27).

$$0.02 < BF/L_L < 0.32$$
 (27")

Furthermore, it is even more preferable that the following conditional expression (27") is satisfied instead of conditional expression (27).

$$0.03 < BF/L_L < 0.28$$
 (27"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

BF denotes a distance on an optical axis from the imageside surface of the second image-side lens up to the image,

Y denotes a maximum image height in an overall optical system.

By satisfying conditional expression (28), it is possible to correct an aberration more favorably, particularly an aberration in a peripheral portion of an image, while shortening the 45 overall length of the optical system.

By making so as not to fall below a lower limit value of conditional expression (28), it is possible to increase a distance between the second image-side lens and the image pickup element. Accordingly, even when a ghost is generated 50 due to multiple reflection between the second image-side lens and the image pickup element, it is possible to prevent the ghost from being incident on the surface of the image pickup element with a high density.

By making so as not to exceed an upper limit value of 55 conditional expression (28), it is possible to prevent the occupancy of a space of the back focus with respect to the overall length of the optical system from becoming excessively large. Accordingly, since there is an increase in the degree of freedom of positions at the time of disposing the lenses, it is 60 possible to correct various aberrations favorably. For instance, by disposing the lens having the function of correcting chromatic aberration in the first lens unit and the second lens unit, and adjusting a positional relationship of these lenses, it is possible to achieve both, the favorable correction of the longitudinal chromatic aberration and the favorable correction of the chromatic aberration of magnification.

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Here, it is preferable that the following conditional expression (28') is satisfied instead of conditional expression (28).

$$0.05 < BF/Y < 6.30$$
 (28')

Moreover, it is more preferable that the following conditional expression (28") is satisfied instead of conditional expression (28).

$$0.10 < BF/Y < 5.67$$
 (28")

Furthermore, it is even more preferable that the following conditional expression (28") is satisfied instead of conditional expression (28).

$$0.15 < BF/Y < 5.10$$
 (28"')

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (29) is satisfied:

$$-0.2 < \phi_{G1o}/R_{G1o} < 3.0$$
 (29)

where.

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 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens, and

 R_{G1o} denotes a radius of curvature of the object-side surface of the first object-side lens.

In an optical system in which, the numerical aperture on the object side has been enlarged and the working distance made long, a diameter of a light beam incident on the first object-side lens is spread sufficiently. By making so as not to fall below a lower limit value of conditional expression (29), even in such optical system, it is possible to suppress the light beam that is incident, from being diverged. As a result, in a lens disposed on the image side of the first object-side lens, it is possible to suppress an occurrence of various aberrations such as the spherical aberration and the coma aberration.

By making so as not to exceed an upper limit value of conditional expression (29), since it is possible to prevent difference in angles of incidence when the off-axis marginal ray is incident on the lens, or in other words, to prevent the difference in an angle of incidence of an upper-side light ray and an angle of incidence of a lower-side light ray from becoming excessively large, it is possible to suppress the occurrence of the coma.

Particularly, in a case in which, the working distance has been secured sufficiently, in the optical system with the large numerical aperture on the object side, it is possible to correct various aberrations such as the coma more favorably while shortening the overall length of the optical system.

Here, it is preferable that the following conditional expression (29') is satisfied instead of conditional expression (29).

$$-0.15 < \phi_{G1o}/R_{G1o} < 2.10$$
 (29)

Moreover, it is more preferable that the following conditional expression (29") is satisfied instead of conditional expression (29).

$$-0.10 < \phi_{G1} / R_{G1o} < 1.47$$
 (29")

Furthermore, it is even more preferable that the following conditional expression (29") is satisfied instead of conditional expression (29).

$$-0.05 < \phi_{G1o} / R_{G1o} < 1.03$$
 (29"")

In the optical system according to the present embodiment, it is preferable that the second lens unit includes four lenses, and at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and an object-side surface of the positive lens from among the positive lenses, which is posi-

tioned nearest to the object side, is a convex surface that is convex toward the object side.

By making such an arrangement, it is possible to correct various aberrations, particularly the chromatic aberration of magnification more favorably, while shortening the overall 5 length of the optical system. In other words, it is possible to make an adjustment to position the principal point of the second lens unit on the object side, and to dispose a plurality of lenses having different optical characteristics. Therefore, it is possible to correct the chromatic aberration and other various aberrations in the second lens unit favorably while shortening a conjugate length (a distance from the object up to the image). As a result, it is possible to correct favorably various aberrations including the chromatic aberration of magnification in the overall optical system while shortening the overall 15 length of the optical system.

In the optical system according to the present embodiment, it is preferable that the first lens unit includes a first image-side lens which is disposed nearest to the image side, and a distance of two lenses positioned on two sides of the stop is 20 fixed, and the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

where,

 ${\rm D}_{G1G2}$ denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes a diameter of the stop.

By satisfying conditional expression (30), it is possible to 30 maintain appropriately a balance between a predetermined refraction effect in the first lens unit and a predetermined refraction effect in the second lens unit, while shortening the overall length of the optical system. As a result, it is possible to correct the chromatic aberration of magnification and other 35 off-axis aberrations more favorably. The predetermined refraction effect is same as the predetermined refraction effect described in conditional expression (20).

By making so as not to exceed an upper limit value of conditional expression (30), it is possible to make the optical 40 system thin while preventing an angle of incidence of an off-axis light beam incident on the second lens unit from becoming excessively small. Therefore, it is possible to suppress the predetermined refraction effect in the first lens unit from becoming excessively large, and moreover not to let the 45 predetermined refraction effect in the second lens unit become excessively small, while maintaining the required imaging magnification. Accordingly, since it is possible to maintain appropriately the balance between the predetermined refraction effect in the first lens unit and the predetermined refraction effect in the second lens unit, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably.

Here, it is preferable that the following conditional expression (30') is satisfied instead of conditional expression (30). 55

$$0.01 < D_{G1G2}/\phi_s < 1.80$$
 (30')

Moreover, it is more preferable that the following conditional expression (30") is satisfied instead of conditional expression (30).

$$0.03 < D_{G1G2}/\phi_s < 1.53$$
 (30")

Furthermore, it is even more preferable that the following conditional expression (30") is satisfied instead of conditional expression (30).

$$0.05 < D_{G1G2}/\phi_s < 1.30$$
 (30"")

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In the optical system according to the eighth embodiment and the optical system according to the ninth embodiment, it is preferable that the following conditional expression (31) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.5$$
 (31)

where,

 L_{G1} denotes a distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\cal L}_{G2}$ denotes a distance on the optical axis from an object-side surface of the second object-side lens up to the image side surface of the second image-side lens.

By making so as not to fall below a lower limit value of conditional expression (31), it is possible to maintain appropriately the positive refractive power of the first lens unit while securing the appropriate thickness of lenses forming the first lens unit. Therefore, it is possible to position the principal point on the object side and to shorten the overall length of the optical system while correcting the longitudinal chromatic aberration favorably.

By making so as not to exceed an upper limit value of conditional expression (31), in a case of securing the appropriate working distance, since it is possible to change the height of a principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually, it is possible to prevent a radius of curvature of a lens in the second lens unit from becoming excessively small. Therefore, it is possible to correct the chromatic aberration of magnification more favorably.

By satisfying conditional expressions (16), (19), (20), and (31), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing sufficient working distance, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (23-1), (24-1), and (31), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (31') is satisfied instead of conditional expression (31).

$$0.14 < L_{G1}/L_{G2} < 1.43$$
 (31)

Moreover, it is more preferable that the following conditional expression (31") is satisfied instead of conditional expression (31).

$$0.20 < L_{GI}/L_{G2} < 1.35$$
 (31")

Furthermore, it is even more favorable that the following conditional expression (31") is satisfied instead of conditional expression (31).

$$0.29 < L_{G1}/L_{G2} < 1.29$$
 (31"")

In the optical system according to the tenth embodiment, it 60 is preferable that the following conditional expression (31-1) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.4$$
 (31-1)

where.

 L_{G1} denotes a distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 L_{G2} denotes a distance on the optical axis from an objectside surface of the second object-side lens up to the image side surface of the second image-side lens.

A technical significance of conditional expression (31-1) is same as the technical significance of conditional expression 5

By satisfying conditional expressions (18) and (31-1), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing the appropriate working distance, and while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical

Here, it is preferable that the following conditional expression (31-1') is satisfied instead of conditional expression (31-15 1).

$$0.14 < L_{G1}/L_{G2} < 1.33$$
 (31-1')

Moreover, it is more preferable that the following conditional expression (31-1") is satisfied instead of conditional 20 expression (31-1).

$$0.20 < L_{G1}/L_{G2} < 1.26$$
 (31-1")

Furthermore, it is even more preferable that the following conditional expression (31-1") is satisfied instead of condi- 25 it is preferable that the following conditional expression (33) tional expression (31-1).

$$0.29 < L_{GI}/L_{G2} < 1.20$$
 (31-1"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (32) 30 is satisfied:

$$0.1 < L_{G1} / L_{sG2} < 1.5$$
 (32)

side surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens.

By satisfying conditional expression (32), it is possible to correct more favorably an aberration in a peripheral portion of 40 the image, particularly the chromatic aberration of magnification while shortening the overall length of the optical sys-

By making so as not to fall below a lower limit value of conditional expression (32), it is possible to secure suffi- 45 ciently a space for disposing the first lens unit. Accordingly, it is possible to secure an appropriate thickness in lenses forming the first lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to dispose a large number of lenses having different optical characteristics. 50 Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration in the first lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the first lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the second lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By making so as not to exceed an upper limit value of conditional expression (32), it is possible to secure sufficiently a space for disposing the second lens unit. Accordingly, it is possible to secure an appropriate thickness in lenses forming the second lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to dispose a large number of lenses having different optical

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characteristics. Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration in the second lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the second lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the first lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the first lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

Here, it is preferable that the following conditional expression (32') is satisfied instead of conditional expression (32).

$$0.14 < L_{G1s}/L_{sG2} < 1.35$$
 (32')

Moreover, it is more preferable that the following conditional expression (32") is satisfied instead of conditional expression (32).

$$0.20 < L_{G1s}/L_{sG2} < 1.22$$
 (32")

Furthermore, it is even more preferable that the following conditional expression (32"") is satisfied instead of conditional expression (32).

$$0.29 < L_{G1s} / L_{sG2} < 1.09$$
 (32"")

In the optical system according to the present embodiment, is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0 \tag{33}$$

 ϕ_{G1max} denotes a maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter of lenses in the second lens unit.

By satisfying conditional expression (33), it is possible to L_{G1s} denotes a distance on the optical axis from the object- 35 maintain appropriately the balance between a predetermined refraction effect in the first lens unit and a predetermined refraction effect in the second lens unit while shortening the overall length of the optical system. As a result, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably.

> By making so as not to fall below a low limit value of conditional expression (33), it is possible to make the optical system thin while preventing a diameter of a lens forming the first lens unit from becoming excessively small. Therefore, in a region on the object side of the first lens unit, it is possible to prevent a light ray height of an off-axis light beam from becoming excessively low. Accordingly, since it is possible to secure appropriately a space in an optical axial direction of the first lens unit, it is possible to correct the chromatic aberration of magnification favorably.

By making so as not to exceed an upper limit value of conditional expression (33), it is possible to make the optical system thin while preventing a diameter of a lens forming the second lens unit from becoming excessively small. In this case, since it is not necessary anymore to make an angle of incidence of an off-axis light beam that is incident on the second lens unit excessively small, it is possible to suppress the predetermined refraction effect in the first lens unit from becoming excessively large, and moreover not to let the predetermined refraction effect in the second lens unit become excessively small while maintaining the required imaging magnification. In such manner, since it is possible to maintain appropriately the balance between the predetermined refraction effect in the first lens unit and the predetermined refraction effect in the second lens unit, it is possible to correct the chromatic aberration of magnification and other off-axis aberrations more favorably.

Here, it is preferable that the following conditional expression (33') is satisfied instead of conditional expression (33).

$$0.84 \le \phi_{G1max}/\phi_{G2max} \le 4.50$$
 (33')

Moreover, it is more preferable that the following conditional expression (33") is satisfied instead of conditional expression (33).

$$0.88 \le \phi_{G1max}/\phi_{G2max} \le 3.50$$
 (33")

Furthermore, it is even more preferable that the following conditional expression (33") is satisfied instead of conditional expression (33).

$$0.93 \le \phi_{G1max}/\phi_{G2max} \le 2.50$$
 (33"")

In the optical system according to the present embodiment, 15 expression (34). it is preferable that the following conditional expression (34) $1.0 < D_{os}/L_{G1}$ is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where.

 D_{os} denotes a distance on an optical axis from the object up to the stop, and

 ${\cal L}_{G1}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

By making so as not to fall below a lower limit value of conditional expression (34), it is possible to secure sufficiently a space for disposing the second lens unit. Accordingly, it is possible to secure an appropriate thickness in lenses forming the second lens unit, and to increase a degree 30 of freedom of selection of curvature of a lens surface, and to dispose a large number of lenses having different optical characteristics. Therefore, it is possible to correct also the chromatic aberration favorably while correcting the monochromatic aberration in the second lens unit. Moreover, as it 35 is possible to correct the longitudinal chromatic aberration in the second lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the first lens unit becomes unnecessary. Accordingly, since the chromatic aberration of magnification in the first lens unit can be corrected 40 favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By making so as not to exceed an upper limit value of conditional expression (34), it is possible to secure sufficiently a space for disposing the first lens unit. Accordingly, it 45 is possible to secure an appropriate thickness in lenses forming the first lens unit, and to increase a degree of freedom of selection of curvature of a lens surface, and to dispose a large number of lenses having different optical characteristics. Therefore, it is possible to correct also the chromatic aberra- 50 tion favorably while correcting the monochromatic aberration in the first lens unit. Moreover, as it is possible to correct the longitudinal chromatic aberration in the first lens unit favorably, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. 55 Accordingly, since the chromatic aberration of magnification in the second lens unit can be corrected favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

By satisfying conditional expressions (16), (19), (20), and 60 (34), it is possible to correct the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (23-1), (24-1), and 65 (34), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more

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favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (18) and (34), it is possible to correct the chromatic aberration of magnification more favorably while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (34') is satisfied instead of conditional expression (34).

$$0.7 < D_{os}/L_{G1} < 3.8$$
 (34')

Moreover, it is more preferable that the following conditional expression (34") is satisfied instead of conditional expression (34).

$$1.0 < D_{os}/L_{G1} < 3.6$$
 (34")

Furthermore, it is even more preferable that the following conditional expression (34") is satisfied instead of conditional expression (34).

$$1.5 < D_{os}/L_{G1} < 3.4$$
 (34"')

In the optical system according to the present embodiment, it is preferable that the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP} / Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5$$
 (36)

where

 ${\rm D}_{ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system,

 ${\rm CRA}_{obj}$ denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 CRA_{img} denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.

By making so as not to fall below a lower limit value of conditional expression (36), since an angle of incidence of an off-axis light beam on an image pickup surface does not become excessively large, it is possible to prevent degradation of an amount of light at periphery more efficiently.

By making so as not to exceed an upper limit value of conditional expression (36), a divergence effect is imparted to a region near an image side of the optical system, and it is possible to make an arrangement of the optical system to be of a telephoto type. As a result, it is possible to shorten the overall length of the optical system.

Satisfying conditional expressions (16), (19), (20), (35), and (36) is advantageous for favorable correction of the chromatic aberration and for shortening the overall length of the optical system while securing the amount of light at periphery.

Satisfying conditional expressions (23-1), (24-1), (35), and (36) is advantageous for favorable correction of the chromatic aberration, and for shortening the overall length of the optical system while securing the amount of light at periphery.

Satisfying conditional expressions (18), (35), and (36) is advantageous for favorable correction of the chromatic aberration, and for shortening the overall length of the optical system while securing the amount of light at periphery.

Here, it is preferable that the following conditional expression (36') is satisfied instead of conditional expression (36).

$$0.01 \le CRA_{obi}/CRA_{img} \le 0.48$$
 (36')

Moreover, it is more preferable that the following conditional expression (36") is satisfied instead of conditional expression (36).

$$0.02 \le CRA_{ob} / CRA_{img} \le 0.46$$
 (36")

Furthermore, it is even more preferable that the following 10 conditional expression (36") is satisfied instead of conditional expression (36).

$$0.03 \le CRA_{obi}/CRA_{img} < 0.44$$
 (36"")

In the optical system according to the present embodiment, it is preferable that the first lens unit includes the first object-side lens, and a lens which disposed to be adjacent to the first object-side lens, and at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

By one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens, on the image side of the first object-side lens, having a positive refractive power, it is possible to position the principal point of the first lens unit on the object side. As a result, it is possible to secure the working distance sufficiently. The first object-side lens and the lens disposed to be adjacent to the first object-side lens, on the image side of the first object-side lens may be in separated state or may be in cemented state.

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the first object-side lens has a positive refractive power. Moreover, it is preferable that the following conditional expression (37) is satisfied:

$$0.05 < f_{G1} / f$$
 (37) 35

where.

 ${\rm f}_{G1o}$ denotes a focal length of the first object-side lens, and f denotes a focal length of an overall optical system.

In the optical system which satisfies conditional expression (20), by imparting the positive refractive power to the first object-side lens, a height of the off-axis marginal ray can be suppressed while positioning the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (37), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

In the optical system which satisfies conditional expression (25), by imparting the positive refractive power to the first object-side lens, the height of the off-axis marginal ray can be suppressed while positioning the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (37), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

Here, it is preferable that the following conditional expression (37') is satisfied instead of conditional expression (37).

$$0.06 < f_{G1} / f < 50.00$$
 (37')

Moreover, it is more preferable that the following conditional expression (37") is satisfied instead of conditional expression (37).

$$0.07 < f_{G1} / f < 25.00$$
 (37")

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Furthermore, it is even more preferable that the following conditional expression (37") is satisfied instead of conditional expression (37).

$$0.10 < f_{G1} / f < 20.00$$
 (37"')

In the optical system according to the ninth embodiment, it is preferable that the first object-side lens has a negative refractive power. Moreover, it is preferable that the following conditional expression (37-1) is satisfied:

$$f_{G1}/f < -0.01$$
 (37-1)

where,

 \mathbf{f}_{Glo} denotes a focal length of the first object-side lens, and f denotes a focal length of an overall optical system.

In the optical system which satisfies conditional expressions (23-1) and (24-1), by imparting the negative refractive power to the first object-side lens, it is possible to secure sufficiently a space for disposing the first lens unit, as well as to maintain appropriately a height of the off-axis marginal ray in a region on the object side of the first lens unit. Furthermore, by satisfying conditional expression (37-1), it is possible to suppress the off-axis marginal ray from being diverged excessively. Accordingly, it is possible to correct aberrations such as the chromatic aberration of magnification favorably.

Here, it is preferable that the following conditional expression (37-1') is satisfied instead of conditional expression (37-1).

$$-500.00 < f_{G1} / f < -0.02$$
 (37-1')

Moreover, it is more preferable that the following conditional expression (37-1") is satisfied instead of conditional expression (37-1).

$$-250.00 < f_{G1} / f < -0.04$$
 (37-1")

Furthermore, it is even more preferable that the following conditional expression (37-1") is satisfied instead of conditional expression (37-1).

$$-100.00 < f_{G1} / f < -0.08$$
 (37-1")

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the object-side surface of the first object-side lens is convex toward the object side. Moreover, it is preferable that the following conditional expression (38) is satisfied:

$$0.02 < R_{G1} / WD$$
 (38)

where

 $R_{{\cal G}{\rm I}o}$ denotes a radius of curvature of the object-side sur- $_{50}$ face of the first object-side lens, and

WD denotes a distance on an optical axis from the object up to an object-side side surface of the first object-side lens.

In the optical system which satisfies the conditional expression (20), by imparting the positive refractive power to the object-side surface of the first object-side lens, a height of the off-axis marginal ray can be suppressed while positioning the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (38), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

In the optical system which satisfies the conditional expression (25), by imparting the positive refractive power to the object-side surface of the first object-side lens, the height of the off-axis marginal ray can be suppressed while position-

ing the principal point of the first lens unit on the object side. Therefore, it is possible to achieve both, enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system. Furthermore, by satisfying conditional expression (38), it is possible to suppress the occurrence of the spherical aberration and the coma more effectively.

Here, it is preferable that the following conditional expression (38') is satisfied instead of conditional expression (38).

$$0.02 < R_{G1} / WD < 20.00$$
 (38°)

Moreover, it is more preferable that the following conditional expression (38") is satisfied instead of conditional expression (38).

$$0.03 < R_{G1} / WD < 15.00$$
 (38")

Furthermore, it is even more preferable that the following conditional expression (38") is satisfied instead of conditional expression (38).

$$0.04 < R_{G1} / WD < 10.00$$
 (38')

In the optical system according to the ninth embodiment, it is preferable that the object-side surface of the first object-side lens is concave toward the object side. Moreover, it is preferable that the following conditional expression (38-1) is 25 satisfied:

$$R_{G1}/WD \le -0.1$$
 (38-1)

where.

 R_{G1o} denotes the radius of curvature of the object-side 30 surface of the first object-side lens, and

WD denotes a distance on an optical axis from the object up to an object-side side surface of the first object-side lens.

In the optical system which satisfies conditional expressions (23-1) and (24-1), by imparting the negative refractive 35 power to the object-side surface of the first object-side lens, it is possible to secure sufficiently a space for disposing the first lens unit, as well as to maintain appropriately the height of the off-axis marginal ray in a region on the object side of the first lens unit. Furthermore, by satisfying conditional expression 40 (38-1), it is possible to suppress divergence of the off-axis marginal ray. Accordingly, it is possible to correct aberrations such as the chromatic aberration of magnification favorably.

Here, it is preferable that the following conditional expression (38-1') is satisfied instead of conditional expression (38-45 1).

$$-250.00 < R_{G1} / WD < -0.14$$
 (38-1')

Moreover, it is more preferable that the following conditional expression (38-1") is satisfied instead of conditional 50 expression (38-1).

$$-100.00 < R_{G1o}/WD < -0.20$$
 (38-1")

Furthermore, it is even more preferable that the following conditional expression (38-1") is satisfied instead of conditional expression (38-1).

$$-50.00 < R_{G1o}/WD < -0.29$$
 (38-1"")

In the optical system according to the present embodiment, it is preferable that the second lens unit includes a predetermined lens unit nearest to the image, and the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and the two single lenses consist in order from the object side, a lens having a negative refractive power, 65 and a lens having one of a positive refractive power and a negative refractive power.

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In the optical system which satisfies conditional expression (20), by further disposing the predetermined lens unit, or in other words, a lens unit having a negative refractive power, at a position nearest to the image side of the second lens unit, it is possible to position the principal point on the object side. Accordingly, since it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually while shortening the overall length of the optical system, it is possible to correct favorably the chromatic aberration of magnification in particular.

In the optical system which satisfies conditional expressions (21), (23-1), and (24-1), by further disposing the predetermined lens unit, or in other words, a lens unit having a negative refractive power, at a position nearest to the image side of the second lens unit, it is possible to position the principal point on the object side. Accordingly, since it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually while shortening the overall length of the optical system, it is possible to correct favorably the chromatic aberration of magnification in particular.

In the optical system which satisfies conditional expressions (18) and (25), by further disposing the predetermined lens unit, or in other words, a lens unit having a negative refractive power, at a position nearest to the image side of the second lens unit, it is possible to position the principal point on the object side. Accordingly, since it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually while shortening the overall length of the optical system, it is possible to correct favorably the chromatic aberration of magnification in particular.

In the optical system according to the present embodiment, it is preferable that an image-side surface of the second image-side lens is concave toward the image side, and that the following conditional expression (39) is satisfied:

$$0.1 \le R_{G2i}/BF \tag{39}$$

where.

 R_{G2t} denotes a radius of curvature of the image-side surface of the second image-side lens, and

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image.

Since it is possible to position the principal point of the second lens unit on the object side, it is possible to shorten the optical system while maintaining a favorable imaging performance.

Here, it is preferable that the following conditional expression (39') is satisfied instead of conditional expression (39).

$$0.2 < R_{G27}/BF$$
 (39')

Moreover, it is more preferable that the following conditional expression (39") is satisfied instead of conditional expression (39).

$$0.4 < R_{G2} / BF$$
 (39")

Furthermore, it is even more preferable that the following conditional expression (39") is satisfied instead of conditional expression (39).

$$0.8 < R_{GO} / BF \tag{39}$$

In the optical system according to the present embodiment, it is preferable that the second lens unit includes a predetermined lens unit nearest to the image, and the positive lens is

disposed on the object side of the predetermined lens unit, and the positive lens is disposed to be adjacent to the predetermined lens unit.

By disposing the positive lens on the object side of the predetermined lens unit, and disposing the positive lens to be 5 adjacent to the predetermined lens unit, it is possible to suppress an angle of incidence of an off-axis light beam on the second lens unit from becoming large, while shortening the overall length of the optical system. As a result, since it is possible to prevent a height of a light ray of the off-axis light beam from becoming excessively high, it is possible to make the optical system thin. Moreover, although a distortion in a positive direction occurs due to a divergence effect in the predetermined lens unit, it is possible to correct the distortion favorably by the positive lens. The predetermined lens and the 15 positive lens may be disposed separately, or may be

In the optical system according to the present embodiment, it is preferable that an image-side surface of the first imageside lens is concave toward the image side, and the following 20 conditional expression (40) is satisfied:

$$0.2 < R_{G1i'}/D_{G1is}$$
 (40)

where.

 R_{GI} denotes a radius of curvature of the image-side surface 25 of the first image-side lens, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop.

By making the image-side surface of the first image-side lens concave toward the image side, it is possible to position 30 the principal point of the first lens unit on the object side. Accordingly, it is possible to secure an appropriate working distance. Moreover since a lens surface which is a concave surface is directed toward the stop, it is possible to suppress the occurrence of the coma in a peripheral portion of the 35 it is preferable that the second lens unit includes at least one image (position at which, the image height is high).

Furthermore, by satisfying conditional expression (40), since it is possible to maintain appropriately the divergence effect in a peripheral portion of the optical system, it is possible to suppress the occurrence of the chromatic coma.

Here, it is preferable that the following conditional expression (40') is satisfied instead of conditional expression (40).

$$0.4 < R_{G1i}/D_{G1is}$$
 (40)

Moreover, it is more preferable that the following condi- 45 tional expression (40") is satisfied instead of conditional expression (40).

$$0.4 < R_{G1i}/D_{G1is}$$
 (40")

Furthermore, it is even more preferable that the following 50 conditional expression (40") is satisfied instead of conditional expression (40).

$$1.6 < R_{G1i}/D_{G1is}$$
 (40"")

In the optical system according to the present embodiment, 55 it is preferable that the first lens unit includes not less than three positive lenses, and at least two positive lenses from among the positive lenses are disposed to be adjacent, and an object-side surface in the two positive lenses disposed to be adjacent is a convex surface which is convex toward the object 60

By making such an arrangement, it is possible to distribute the positive refractive power in the first lens unit to three or more than three lenses, and to dispose each lens at a different position. As a result, it is possible to converge a light beam 65 incident with a high numerical aperture while suppressing an occurrence of aberration, and to correct the curvature of field

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and the chromatic aberration of magnification favorably. Furthermore, by disposing two of the three or more than three lenses to be adjacent, and letting the object-side surface to be a convex surface convex toward the object side, it is possible to correct the spherical aberration favorably.

In the optical system according to the present embodiment, it is preferable that from among the three or more than three positive lenses, at least one positive lens is an aspherical lens, and at least one surface of the aspherical lens is an aspherical

By making such an arrangement, it is possible to correct the off-axis aberration of higher order.

In the optical system according to the present embodiment, it is preferable that the first lens unit includes at least one cemented lens.

By cementing a lens having a function of correcting the chromatic aberration with another lens to form a cemented lens, and by disposing the cemented lens in the first lens unit, it is possible to suppress the occurrence of the chromatic aberration of magnification simultaneously while correcting the longitudinal chromatic aberration in the first lens unit. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification in the optical system favorably.

In the optical system according to the present embodiment, it is preferable that a positive lens is disposed on the object side of the cemented lens in the first lens unit, and the positive lens is a single lens.

By making such an arrangement, it is possible to distribute the positive refractive power in the first lens unit to the cemented lens and the positive lens. As a result, it is possible to correct the spherical aberration more favorably.

In the optical system according to the present embodiment, cemented lens.

By cementing a lens having a function of correcting the chromatic aberration with another lens to form a cemented lens, and by disposing the cemented lens in the second lens unit, it is possible to suppress the occurrence of the chromatic aberration of magnification simultaneously while correcting the longitudinal chromatic aberration in the second lens unit. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification in the optical system favorably.

In the optical system according to the present embodiment, it is preferable that a positive lens is disposed on the image side of the cemented lens in the second lens unit, and the positive lens is a single lens.

By making such an arrangement, it is possible to distribute the positive refractive power in the second lens unit to the cemented lens and the positive lens. As a result, it is possible to correct the spherical aberration more favorably.

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the first object-side lens has a positive refractive power, and the first object-side lens is either a single lens or a cemented lens.

By imparting the positive refractive power to the first object-side lens, it is possible to position the principal point of the first lens unit on the object side as much as possible. As a result, it is possible to achieve both, securing an appropriate working distance and small-sizing of the optical system. In a case in which, further longer working distance is necessary, it is preferable to make such arrangement.

It is preferable that the optical system according to the present embodiment includes at least one lens having an

inflection point, and in the lens having the inflection point, the number of inflection points in a shape of a lens surface is one or more than one.

By making such an arrangement, it is possible to correct the off-axis aberration of higher order favorably.

In the optical system according to the present embodiment, it is preferable that a shape of at least one lens surface of the second image-side lens is a shape having an inflection point.

By making such an arrangement, it is possible to correct the off-axis aberration of higher order favorably, and apart from this, it is possible to achieve both, the small-sizing of the optical system and reduction of an angle of incidence on the image pickup element. For small-sizing of the optical system, it is desirable to make an arrangement such that in the second lens unit, a refractive power in a region closer to the image side becomes a negative refractive power, and accordingly, to position the principal point of the second lens unit on the object side. Moreover, for reducing the angle of incidence on the image pickup element, at least one surface of the second image-side lens is let to have a shape having at least one 20 inflection point. By making such an arrangement, it is possible to make small an angle of incidence of an off-axis light beam on the image surface.

In the optical system according to the present embodiment, it is preferable that the first lens unit includes at least one 25 negative lens, and the negative lens is a single lens.

By making such an arrangement, it is possible to correct the chromatic aberration sufficiently in the first lens unit. As a result, it is possible to correct the chromatic aberration of magnification favorably while correcting the longitudinal 30 chromatic aberration in the overall optical system.

In the optical system according to the present embodiment, it is preferable that the first image-side lens is a cemented lens.

In the first lens unit, by disposing a negative lens near the stop, it is possible to correct favorably the longitudinal chro- 35 matic aberration and the curvature of field simultaneously. Here, by disposing a positive lens at a position adjacent to the negative lens, and cementing the negative lens and the positive lens, it is possible to suppress the occurrence of the chromatic aberration of magnification.

Moreover, in the optical system according to the present embodiment, it is preferable that the second object-side lens is a cemented lens.

In the second lens unit, by disposing a negative lens near the stop, it is possible to correct favorably the longitudinal 45 chromatic aberration and the curvature of field simultaneously. Here, by disposing a positive lens at a position adjacent to the negative lens, and cementing the negative lens and the positive lens, it is possible to suppress the occurrence of the chromatic aberration of magnification.

In the optical system according to the eighth embodiment, it is preferable that at the time of focusing, some of the lenses from among the plurality of lenses in the second lens unit move in an optical axial direction.

Since the second lens unit is positioned on the image side of 55 tional expression (41). the first lens unit, a light beam diameter in the second lens unit is smaller than a light beam diameter in the first lens unit. Therefore, even when a lens is moved in the second lens unit, a fluctuation in aberration is small. Therefore, when the movement of lenses at the time of focusing is carried out by using some of the lenses from among the plurality of lenses in the second lens unit, it is possible to make small the fluctuation in aberration due to the movement of the lenses.

In the optical system according to the eighth embodiment, it is preferable that at the time of focusing, an optical system from the first-object side lens up to the second image-side lens moves integrally in the optical axial direction.

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In the optical system according to the present embodiment, it is preferable that at the time of focusing, an airspace from the first object-side lens up to the second image-side lens does not change.

By making such an arrangement, at the time of focusing, a positional relationship of lenses (single lens or cemented lens) positioned on both sides of the stop does not change. As a result, since a balance of the chromatic aberration of magnification in the first lens unit and the chromatic aberration of magnification in the second lens unit is not disrupted, it is possible to maintain a favorable imaging performance even when the focusing is carried out. In the first lens unit and the second lens unit, it is desirable that a lens and a pair of lenses having a significant effect of correcting the chromatic aberration is disposed near the stop for correcting the chromatic aberration of magnification favorably.

In the optical system according to the eighth embodiment, it is preferable that the following conditional expression (37-2) is satisfied:

$$0.5 < f_{G1o} / f < 100$$
 (37-2)

where.

 \mathbf{f}_{G1o} denotes a focal length of the first object-side lens, and f denotes a focal length of an overall optical system.

Moreover, in the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (41) is satisfied:

$$0.5 < f_{G1} / f_{G1} < 20$$
 (41)

where,

 f_{G10} denotes a focal length of the first object-side lens, and \mathbf{f}_{G1} denotes a focal length of the first lens unit.

By making so as not to fall below a lower limit value of conditional expression (41), it is possible to prevent the positive refractive power of the first object-side lens from becoming excessively small. Accordingly, it is possible to position the principal point of the first lens unit on the object side as much as possible. As a result, it is possible to achieve both, securing an appropriate working distance and small-sizing of the optical system. In a case in which, further longer working distance is necessary, it is preferable to make such arrange-

Here, it is preferable that the following conditional expression (41') is satisfied instead of conditional expression (41).

$$0.71 < f_{G1} / f_{G1} < 10.00$$
 (41')

Moreover, it is more preferable that the following conditional expression (41") is satisfied instead of conditional 50 expression (41).

$$1.00 < f_{G1} / f_{G1} < 7.00$$
 (41")

Furthermore, it is even more preferable that the following conditional expression (41"") is satisfied instead of condi-

$$1.67 < f_{G1} / f_{G1} < 5.00$$
 (41"')

In the optical system according to the present embodiment, it is preferable that the following conditional expression (42) 60 is satisfied:

$$0.01 < 1/\nu d_{G1min} - 1/\nu_{G1max}$$
 (42)

 vd_{G1min} denotes a smallest Abbe's number from among 65 Abbe's numbers for lenses forming the first lens unit, and

 vd_{G1max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit.

In the optical system according to the present embodiment, it is preferable that the following (i) and (ii) have been realized. (i) Enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system, (ii) Favorable correction of the longitudinal chromatic aberration and the chromatic aberration of magnification. Conditional expression (42) is an expression for achieving both of (i) and (ii).

By making so as not to fall below a lower limit value of conditional expression (42), it is possible to suppress the 10 occurrence of the longitudinal chromatic aberration in the first lens unit. Moreover, as it is possible to suppress the occurrence of the longitudinal chromatic aberration in the first lens unit, an excessive correction of the longitudinal chromatic aberration in the second lens unit becomes unnecessary. Accordingly, since the correction of the chromatic aberration of magnification in the second lens unit can be carried out favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

Here, it is preferable that the following conditional expression (42') is satisfied instead of conditional expression (42).

$$0.011 < 1/v d_{G1min} - 1/v d_{G1max}$$
 (42')

Moreover, it is more preferable that the following conditional expression (42") is satisfied instead of conditional expression (42).

$$0.014 < 1/\nu d_{G1min} - 1/\nu d_{G1max}$$
 (42")

Furthermore, it is even more preferable that the following 30 conditional expression (42") is satisfied instead of conditional expression (42).

$$0.020 < 1/\nu d_{G1min} - 1/\nu d_{G1max}$$
 (42"")

In the optical system according to the present embodiment, it is preferable that the following conditional expression (43) is satisfied:

$$0.01 < 1/\nu d_{G2min} - 1/\nu d_{G2max}$$
 (43)

where,

 $\operatorname{vd}_{G2min}$ denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and $\operatorname{vd}_{G2max}$ denotes a largest Abbe's number from among Abbe's numbers for lenses forming the second lens unit.

In the optical system according to the present embodiment, it is preferable that the aforementioned (i) and (ii) have been realized. Conditional expression (43) is an expression for achieving both of (i) and (ii).

By making so as not to fall below a lower limit value of conditional expression (43), it is possible to suppress the occurrence of the longitudinal chromatic aberration in the second lens unit. Moreover, as it is possible to suppress the occurrence of the longitudinal chromatic aberration in the second lens unit, an excessive correction of the longitudinal chromatic aberration in the first lens unit becomes unnecessary. Accordingly, since the correction of the chromatic aberration of magnification in the second lens unit can be carried out favorably, it is possible to correct the chromatic aberration of magnification in the overall optical system favorably.

Here, it is preferable that the following conditional expression (43') is satisfied instead of conditional expression (43).

$$0.011 < 1/vd_{G2min} - 1/vd_{G2max}$$
 (43')

Moreover, it is more preferable that the following conditional expression (43") is satisfied instead of conditional expression ((43).

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Furthermore, it is even more preferable that the following conditional expression (43") is satisfied instead of conditional expression (43).

$$0.020 < 1/v d_{G2min} - 1/v d_{G2max}$$
 (43"')

It is preferable that the optical system according to the present embodiment includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where,

 θ_{gF} denotes a partial dispersion ratio of the positive lens, and is expressed by θ_{gF} =(ng-nF)/(nF-nC), where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

In the optical system according to the present embodiment, it is preferable that the aforementioned (i) and (ii) have been realized. Conditional expression (44) is an expression for achieving both of (i) and (ii).

When the longitudinal chromatic aberration and the chromatic aberration of magnification for the d-line and the C-line have been corrected favorably, by disposing the positive lens satisfying conditional expression (44) in the optical system, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification for the g-line favorably.

A material satisfying conditional expression (44), in many cases, is a material having a high dispersion in general. Therefore, using a material which satisfies conditional expression (44) for a lens having a positive refractive power means imparting a function of correcting a chromatic aberration which is opposite to a usual case, to the lens. However, in a case of carrying out more favorable correction of chromatic aberration, it is desirable to use a material which satisfies conditional expression (44), for the lens having a positive refractive power.

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the lens satisfying conditional expression (44) is included in the first lens unit.

When an attempt is made to secure an appropriate working distance in the optical system, in many cases, an aberration in the first lens unit is outspread to the second lens unit. Therefore, it is desirable to correct favorably the chromatic aberration for the g-line solely in the first lens unit. By doing so, it is possible to correct the chromatic aberration for the g-line favorably, solely in the first lens unit.

In the optical system according to the present embodiment, it is preferable that the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

where

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 ${\rm D}_{p1s}$ denotes a distance on the optical axis from an object-side surface of the positive lens up to the stop, and

 ${\cal L}_{G1s}$ denotes a distance on the optical axis from an object-side surface of the first object-side lens up to the stop.

By satisfying conditional expression (45), it is possible to position the principal point of the first lens unit on the object side while correcting the chromatic aberration favorably. As a result, small-sizing of the optical system is possible while securing the working distance to a fixed amount.

Here, it is preferable that the following conditional expression (45') is satisfied instead of conditional expression (45).

Moreover, it is more preferable that the following conditional expression (45") is satisfied instead of conditional expression (45).

$$0.50 < D_{p1s}/L_{G1s} \le 1.00$$
 (45")

Furthermore, it is even more preferable that the following conditional expression (45") is satisfied instead of conditional expression (45).

$$0.70 < D_{p1s}/L_{G1S} \le 1.00$$
 (45")

In the optical system according to the present embodiment, it is preferable that the first lens unit includes not less than two negative lenses that satisfy the following conditional expression (46):

$$0.01 < 1/v d_{G1n} - 1/v d_{G1max}$$
 (46)

 vd_{G1n} denotes a smallest Abbe's number for the negative lens forming the first lens unit, and

Abbe's numbers for lenses forming the first lens unit.

By satisfying conditional expression (46), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably. Two or more than two negative lenses which satisfy conditional 25 expression (46), or in other words, two or more than two negative lenses which have a function of correcting the chromatic aberration are used, and are disposed to have an appropriate positional relation. Accordingly, when the occurrence of the longitudinal chromatic aberration in the first lens unit has been suppressed, it is possible to correct the chromatic aberration of magnification in the first lens unit favorably. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification in the overall optical system favorably. Particularly, in a case of 35 a magnifying optical system, for correcting the chromatic aberration of magnification in the first lens unit favorably, it is desirable to satisfy conditional expression (46).

Moreover, in the optical system according to the present embodiment, it is preferable that the two or more than two 40 negative lenses which satisfy conditional expression (46) include an object-side negative lens which is disposed nearest to the object, and an image-side negative lens which is disposed nearest to the image, and the object-side negative lens satisfies the following conditional expression (47):

$$0.2 < D_{non}/L_{G1s} < 0.9$$
 (47)

 D_{noni} denotes a distance on the optical axis from an objectside surface of the object-side negative lens up to an object- 50 side surface of the image-side negative lens, and

 L_{G1s} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the stop.

By satisfying conditional expression (47), it is possible to correct the longitudinal chromatic aberration and the chro- 55 matic aberration of magnification more favorably. Two or more than two negative lenses which satisfy conditional expression (46), or in other words, two or more than to negative lenses having a function of correcting the chromatic aberration are used, and these negative lenses are disposed at 60 positions which satisfy conditional expression (47). Accordingly, when the occurrence of the longitudinal chromatic aberration in the first lens unit has been suppressed, it is possible to correct the chromatic aberration of magnification in the first lens unit more favorably. As a result, it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification of the overall lens system

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more favorably. Particularly, in a case of a magnifying optical system, for correcting the chromatic aberration of magnification in the first lens unit favorably, it is desirable to satisfy conditional expression (47).

Here, it is preferable that the following conditional expression (47') is satisfied instead of conditional expression (47).

$$0.21 < D_{non} / L_{G1s} < 0.86$$
 (47')

Moreover, it is more preferable that the following condi-10 tional expression (47") is satisfied instead of conditional expression (47).

$$0.22 < D_{noni}/L_{G1s} < 0.81$$
 (47")

Furthermore, it is even more preferable that the following 15 conditional expression (47"") is satisfied instead of conditional expression (47).

$$0.23 < D_{noni}/L_{G1s} < 0.77$$
 (47")

In the optical system according to the present embodiment, vd_{G1max} denotes a largest Abbe's number from among 20 it is preferable that the first lens unit has a positive refractive power, and includes at least one diffractive optical element.

> A height of an axial marginal ray is high in the first lens unit. Therefore, by letting the refractive power of the first lens unit to be a positive refractive power, and disposing the diffractive optical element in the first lens unit, it is possible to suppress the occurrence of the longitudinal chromatic aberration in the first lens unit.

> In the optical system according to the present embodiment, it is preferable to dispose at least one diffractive optical element at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 < D_{DLs}/D_{Glis} \tag{48}$$

where.

D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{Glis} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop.

At the position in the first lens unit at which, conditional expression (48) is satisfied, since the height of the principal ray becomes comparatively higher, by disposing the diffractive optical element at that position, it is possible to correct the chromatic aberration of magnification for the F-line and the g-line in particular, more favorably. To be more precise, D_{DLs} is a distance from a diffractive surface of the diffractive optical element up to the stop.

In the optical system according to the present embodiment, it is preferable to dispose at least one diffractive optical element at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

 \mathbf{D}_{sDL} denotes a distance on the optical axis from the stop up to the diffractive optical element, and

 L_{sG} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens.

At the position in the second lens unit at which, conditional expression (49) is satisfied, since the height of the principal ray becomes comparatively higher, by disposing the diffractive optical element at that position, it is possible to correct the chromatic aberration of magnification for the F-line and the g-line in particular, more favorably. To be more precise, D_{sDL} is a distance from the stop up to a diffractive surface of the diffractive optical element.

Here, it is preferable that the following conditional expression (49') is satisfied instead of conditional expression (49).

$$0.21 < D_{sDL}/L_{sG2} < 0.86$$
 (49')

Moreover, it is more preferable that the following conditional expression (49") is satisfied instead of conditional expression (49).

$$0.22 < D_{sDL}/L_{sG2} < 0.86$$
 (49)

Furthermore, it is even more preferable that the following 10 conditional expression (49") is satisfied instead of conditional expression (49).

$$0.23 < D_{sDL}/L_{sG2} < 0.86$$
 (49"")

Moreover, it is preferable that the optical system according to the present embodiment includes a negative lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max}$$
 (50)

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51) 20

where,

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 D_{os} denotes a distance on the optical axis from the object up to the stop.

For achieving both, shortening of the overall length of the optical system and favorable correction of the chromatic aberration and the curvature of field, it is preferable to satisfy conditional expressions (50) and (51).

By making so as not to fall below lower limit values of conditional expression (50) and (51), it is possible to secure a thickness of the negative lens appropriately.

By making so as not to exceed an upper limit values of conditional expressions (50) and (51), it is possible to dispose the negative lens having a function of correcting the chromatic aberration because of high dispersion, near the stop. The height of an axial marginal ray being low near the stop, it is possible to correct favorably the chromatic aberration and the curvature of field simultaneously by the negative lens.

Here, it is preferable that the following conditional expression (51') is satisfied instead of conditional expression (51).

$$0.01 < D_{n1s}/D_{os} < 0.29$$
 (51')

Moreover, it is more preferable that the following conditional expression (51") is satisfied instead of conditional expression (51).

$$0.02 < D_{n1s}/D_{os} < 0.27$$
 (51")

Furthermore, it is even more preferable that the following conditional expression (51") is satisfied instead of conditional expression (51).

$$0.03 < D_{n1s}/D_{os} < 0.26$$
 (51"")

It is preferable that the optical system according to the present embodiment includes a negative lens which satisfies the following conditional expressions (52) and (53):

$$0.01 < 1/v d_{n2} - 1/v d_{G2max}$$
 (52)

$$0 < D_{m2}/D_{si} < 0.4$$
 (53)

where.

 vd_{n2} denotes Abbe's number for the negative lens,

 vd_{G2max} denotes a largest Abbe's number from among the Abbe's numbers for lenses forming the second lens unit,

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 ${\rm D}_{sn2}$ denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 D_{si} denotes a distance on the optical axis from the stop up to the image.

For achieving both, shortening of the overall length of the optical system and favorable correction of the chromatic aberration and the curvature of field, it is preferable to satisfy conditional expressions (52) and (53).

By making so as not to fall below lower limit values of conditional expressions (52) and (53), it is possible to secure a thickness of the negative lens appropriately.

By making so as not to exceed an upper limit values of conditional expressions (52) and (53), it is possible to dispose the negative lens having a function of correcting the chromatic aberration because of high dispersion, near the stop. The height of an axial marginal ray being low near the stop, it is possible to correct favorably the chromatic aberration and the curvature of field simultaneously by the negative lens.

Here, it is preferable that the following conditional expression (53') is satisfied instead of conditional expression (53).

$$0.01 < D_{sn2}/D_{si} < 0.38$$
 (53')

Moreover, it is more preferable that the following conditional expression (53") is satisfied instead of conditional expression (53).

$$0.02 < D_{sn2}/D_{si} < 0.36$$
 (53")

Furthermore, it is even more preferable that the following conditional expression (53") is satisfied instead of conditional expression (53).

$$0.03 < D_{sy2}/D_{si} < 0.34$$
 (53"')

It is preferable that the optical system according to the present embodiment includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3} / D_{si} < 1$$
 (54)

where,

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 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 D_{st} denotes a distance on the optical axis from the stop up to the image.

For achieving both, shortening of the overall length of the optical system and favorable correction of the off-axis aberration such as the chromatic aberration of magnification, it is preferable to satisfy conditional expression (54).

By making so as not to fall below a lower limit value of conditional expression (54), in the second lens unit, it is possible to dispose the negative lens in a region closer to the image side. Accordingly, since it is possible to position the principal point on the object side, even if the overall length of the optical system is shortened, it becomes possible to change the height of the principal ray emerged from the stop and reaching the periphery of the image in the second lens unit comparatively gradually. As a result it is possible to correct favorably the chromatic aberration of magnification in particular.

By making so as not to exceed an upper limit value of conditional expression (54), it is possible to increase a distance between the negative lens and the image pickup element. Therefore, even when a ghost is generated due to multiple reflection between the negative lens and the image pickup element, it is possible to prevent the ghost from being incident on a surface of the image pickup element with a high density.

Here, it is preferable that the following conditional expression (54') is satisfied instead of conditional expression (54).

$$0.63 < D_{sn3}/D_{si} < 0.98$$
 (54')

Moreover, it is more preferable that the following conditional expression (54") is satisfied instead of conditional expression (54).

$$0.66 < D_{sn3}/D_{si} < 0.96$$
 (54")

Furthermore, it is even more preferable that the following conditional expression (54") is satisfied instead of conditional expression (54).

$$0.70 < D_{sn3} / D_{si} < 0.94$$
 (54"")

It is preferable that the optical system according to the present embodiment includes a positive lens at a position which satisfies the following conditional expression (55):

$$0.3 < D_{p2s}/D_{os} < 0.99$$
 (55)

where.

 ${\rm D}_{p2s}$ denotes a distance on the optical axis from an object- 20 side surface of the positive lens up to the stop, and

 D_{os} denotes a distance on the optical axis from object up to the stop.

For achieving both, shortening of the overall length of the optical system and favorable correction of the chromatic aberration of magnification and the off-axis aberration, it is preferable to satisfy conditional expression (55).

By making so as not to fall below a lower limit value of conditional expression (55), it is possible to dispose the positive lens on the object side. Accordingly, since it is possible to position the principal point of the first lens unit on the object side, it is possible to secure an appropriate working distance.

By making so as not to exceed an upper limit value of conditional expression (55), it is possible to prevent the positive lens from coming too close to the object. As a result it is possible to secure an appropriate working distance.

Here, it is preferable that the following conditional expression (55') is satisfied instead of conditional expression (55).

$$0.35 < D_{n2} / D_{cr} < 0.89$$
 (55')

Moreover, it is more preferable that the following conditional expression (55") is satisfied instead of conditional expression (55).

$$0.42 < D_{p2s}/D_{os} < 0.80$$
 (55") 45

Furthermore, it is even more preferable that the following conditional expression (55") is satisfied instead of conditional expression (55).

$$0.49 < D_{p2s}/D_{os} < 0.70$$
 (55")

In the optical system according to the eighth embodiment, it is preferable that, instead of conditional expression (55), the following conditional expression (55-1) is satisfied.

$$0.3 < D_{p2s}/D_{os} < 0.7$$
 (55-1)

In the optical system according to the ninth embodiment, it is preferable that, instead of conditional expression (55), the following conditional expression (55-2) is satisfied.

$$0.5 < D_{p2s}/D_{os} < 0.99$$
 (55-2)

In the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and that the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where

 ${\rm L}_L$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object up to the image,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the image.

By making so as not to fall below a lower limit value of conditional expression (56), even in an optical system of which, the overall length is shortened, since it becomes possible to change the height of a principal ray emerged from a periphery of the object and reaching a periphery of the image comparatively gradually, it is possible to prevent the radius of curvature of a lens in the optical system from becoming excessively small. As a result, it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification.

By satisfying conditional expressions (16), (19), (20), and (56), it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification more effectively while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (25) and (56), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing the working distance appropriately, and carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (56') is satisfied instead of conditional expression (56).

$$0.87 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

Moreover, it is more preferable that the following conditional expression (56") is satisfied instead of conditional expression (56).

$$0.96 < L_I/D_{oi} + 0.07 \times WD/BF$$
 (56")

Furthermore, it is even more preferable that the following conditional expression (56") is satisfied instead of conditional expression (56).

$$1.07 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56"')

Moreover, in the optical system according to the eighth embodiment and the optical system according to the tenth embodiment, it is preferable that the following conditional expression (57) is satisfied:

$$D_{os}/L_{GI}$$
 = 0.39×WD/BF<1.8 (57)

where

 ${\cal D}_{os}$ denotes a distance on the optical axis from the object up 55 to the stop,

 ${\rm L}_{G1}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the image.

By making so as not to exceed an upper limit value of conditional expression (57), even in an optical system of which, the overall length is shortened, it becomes possible to change the height of a principal ray emerged from a periphery of the object and reaching a periphery of the image compara-

tively gradually, and it is possible to prevent the radius of curvature of a lens in the optical system from becoming excessively small. Therefore, it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification.

By satisfying conditional expressions (16), (19), (20), and (57), it is possible to suppress the occurrence of the longitudinal chromatic aberration and the chromatic aberration of magnification more effectively while carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

By satisfying conditional expressions (25) and (57), it is possible to correct the longitudinal chromatic aberration and the chromatic aberration of magnification more favorably while securing the working distance appropriately, and carrying out enlargement of the numerical aperture on the object side and shortening of the overall length of the optical system.

Here, it is preferable that the following conditional expression (57') is satisfied instead of conditional expression (57).

$$D_{os}/L_{G1}=0.39 \times WD/BF < 1.53$$
 (57')

Moreover, it is more preferable that the following conditional expression (57") is satisfied instead of conditional expression (57).

$$D_{os}/L_{G1}$$
=0.39×*WD/BF*<1.40 (57")

Furthermore, it is even more preferable that the following conditional expression (57") is satisfied instead of conditional expression (57).

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.30 (57"")

Moreover, an image pickup apparatus of the present embodiment is characterized by including the abovementioned optical system and the image pickup element.

Moreover, an image pickup system of the present embodi- 35 ment is characterized by including the image pickup apparatus, a stage which holds an object, and an illuminating unit which illuminates the object.

By illuminating the object by the illuminating unit, since it is possible to reduce a noise at the time of image pickup, it is 40 lenses from the lens L1 to the lens L10. possible to acquire an image with a high resolution.

Moreover, in the image pickup system of the present embodiment, it is preferable that the image pickup apparatus and the stage are integrated.

Since the numerical aperture on the object side of the 45 optical system according to the present embodiment is large, the optical system has a high resolution, but a depth of field becomes shallow. Therefore, in the image pickup system using the optical system according to the present embodiment, it is preferable to integrate the image pickup apparatus 50 and the stage which holds the object. By integrating the image pickup apparatus and the stage, since it is possible to maintain relative positions and a relative distance of the image pickup apparatus and the object to be fixed, it is possible to acquire an image with a high resolution.

Regarding each conditional expression, by restricting one of or both an upper limit value and a lower limit value, since it is possible to make that function more assured, it is preferable to apply restriction. Moreover, regarding each conditional expression, only an upper limit value or a lower limit 60 value of a numerical range of a further restricted conditional expression may be restricted. Moreover, with regard to restricting the numerical range of a conditional expression, the upper limit value or the lower limit value of each conditional expression described above may be an upper limit value or a lower limit value of a conditional expression other than those described above.

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An optical system according to an example 1 will be described below. FIG. 1 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 1. Moreover, FIG. 2A, FIG. 2B, FIG. 2C, and FIG. 2D are aberration diagrams of the optical system according to the example 1.

In the aberration diagrams shown in FIG. 2A, FIG. 2B, FIG. 2C, and FIG. 2D, 'FIY' denotes the maximum image height. Symbols in the aberration diagrams are same even in examples that will be described later. Moreover, in aberration diagrams of examples from the example 1 to an example 7, four aberration diagrams in order from left show a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC).

The optical system according to the example 1, as shown in FIG. 1, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. In the 20 examples from the example 1 to the example 7, in lens crosssectional views, I denotes an image pickup surface of an image pickup element. The optical system according to the example 1 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.6 μm to 1.2 μm.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a biconcave negative lens L4, and a positive meniscus lens L5 having a convex surface directed toward the object side.

The lens unit Gr includes a positive meniscus lens L6 having a convex surface directed toward the image side, a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, and the biconvex positive lens L10.

The aperture stop S is disposed between the lens L5 and the

An aspheric surface is provided to both surfaces of all the

The optical system according to the example 1 includes five pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L10, the lens L2 and the lens L9, the lens L3 and the lens L8, the lens L4 and the lens L7, and the lens L5 and the lens L6. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 2 of the present invention will be described below. FIG. 3 is a crosssectional view along an optical axis showing an optical arrangement of the optical system according to the example 2. Moreover, FIG. 4A, FIG. 4B, FIG. 4C, and FIG. 4D are aberration diagrams of the optical system according to the example 2.

The optical system according to the example 2, as shown in FIG. 3, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 2 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.6 μm to 1.2 μm.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a biconcave negative lens L4, and a positive meniscus lens L5 having a convex surface directed toward the object side.

The lens unit Gr includes a positive meniscus lens L6 having a convex surface directed toward the image side, a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, and the biconvex positive lens L10.

The aperture stop S is disposed between the lens L5 and the lens L6.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L10.

The optical system according to the example 2 includes five pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L10, the lens L2 and the lens L9, the lens L3 and the lens L8, the lens L4 and the lens L7, and the lens L5 and the lens L6. I5 Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair differ slightly.

Next, an optical system according to an example 3 will be described below. FIG. 5 is a cross-sectional view along an optical axis showing an optical arrangement of the optical 20 system according to the example 3. Moreover, FIG. 6A, FIG. 6B, FIG. 6C, and FIG. 6D are aberration diagrams of the optical system according to the example 3.

The optical system according to the example 3, as shown in FIG. 5, includes in order from an object side, a lens unit Gf $\,^2$ 5 having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 3 is suitable for an image pickup element for which, a pixel pitch is in a range of $0.6 \, \mu m$ to $1.2 \, \mu m$.

The lens unit Gf includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward an image side, a negative meniscus lens L3 having a convex surface directed toward the object side, a negative meniscus lens L4 having a convex surface directed toward the 35 image side, a biconcave negative lens L5, and a positive meniscus lens L6 having a convex surface directed toward the object side.

The lens unit Gr includes a positive meniscus lens L7 having a convex surface directed toward the image side, a 40 biconcave negative lens L8, a negative meniscus lens L9 having a convex surface directed toward the object side, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the object side, and a biconvex positive lens L12.

The aperture stop S is disposed between the lens L6 and the lens L7.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L12.

The optical system according to the example 3 includes six pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L12, the lens L2 and the lens L11, the lens L3 and the lens L10, the lens L4 and the lens L9, the lens L5 and the lens L8, and the 55 lens L6 and the lens L7. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 4 of the present invention will be described below. FIG. **7** is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 4. Moreover, FIG. **8**A, FIG. **8**B, FIG. **8**C, and FIG. **8**D are aberration diagrams of the optical system according to the example 4.

The optical system according to the example 4, as shown in FIG. 7, includes in order from an object side, a lens unit Gf

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having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 4 is suitable for an image pickup element for which, a pixel pitch is in a range of $0.6\,\mu m$ to $1.2\,\mu m$.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a negative meniscus lens L4 having a convex surface directed toward the object side, and a biconvex positive lens L5.

The lens unit Gr includes a biconvex positive lens L6, a negative meniscus lens L7 having a convex surface directed toward the image side, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, a negative meniscus lens L10 having a convex surface directed toward the image side, and a biconvex positive lens L11.

The aperture stop S is disposed between the lens L5 and the lens L6.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L11.

The optical system according to the example 4 includes four pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L1 and the lens L11, the lens L3 and the lens L8, the lens L4 and the lens L7, and the lens L5 and the lens L6. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 5 will be described below. FIG. 9 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 5. Moreover, FIG. 10A, FIG. 10B, FIG. 10C, and FIG. 10D are aberration diagrams of the optical system according to the example 5.

The optical system according to the example 5, as shown in FIG. 9, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 5 is suitable for an image pickup element for which, a pixel pitch is in a range of $1.0 \, \mu m$ to $1.6 \, \mu m$.

The lens unit Gf includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward an image side, a negative meniscus lens L4 having a convex surface directed toward the object side, and a biconvex positive lens L5.

The lens unit Gr includes a biconvex positive lens L6, a negative meniscus lens L7 having a convex surface directed toward the image side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the image side, a biconcave negative lens L10, and a biconvex positive lens L11.

The aperture stop S is disposed between the lens L5 and the lens L6.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L11.

The optical system according to the example 5 includes two pairs of lenses which satisfy conditional expressions (1), (2), and (3). The pairs of lenses are the lens L3 and the lens L8, and the lens L5 and the lens L6. Moreover, in the pairs of lenses, a shape of one lens in the pair and a shape of the other lens in the pair are same.

Next, an optical system according to an example 6 will be described below. FIG. 11 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 6. Moreover, FIG. 12A, FIG. 12B, FIG. 12C, and FIG. 12D are aberration diagrams of 5 the optical system according to the example 6.

The optical system according to the example 6, as shown in FIG. 11, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical system according to the example 6 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.9 μm to 1.5 μm.

The lens unit Gf includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 15 positive meniscus lens L2 having a convex surface directed toward the object side, a biconcave negative lens L3, and a biconvex positive lens L4.

The lens unit Gr includes a biconvex positive lens L5, a biconcave negative lens L6, a positive meniscus lens L7 hav- 20 ing a convex surface directed toward the image side, and a biconcave negative lens L8.

The aperture stop S is positioned on the image side of the biconvex positive lens L4, and on the object side of a vertex of the image-side surface of the biconvex positive lens L4.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L8.

The optical system according to the example 6 does not include a pair of lenses which satisfies conditional expressions (1), (2), and (3).

Next, an optical system according to an example 7 will be described below. FIG. 13 is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 7. Moreover, FIG. 14A, the optical system according to the example 7.

The optical system according to the example 7, as shown in FIG. 13, includes in order from an object side, a lens unit Gf having a positive refractive power, an aperture stop S, and a lens unit Gr having a positive refractive power. The optical 40 system according to the example 7 is suitable for an image pickup element for which, a pixel pitch is in a range of 0.7 μm to 1.3 μm.

The lens unit Gf includes a biconcave negative lens L1, a positive meniscus lens L2 having a convex surface directed 45 toward the object side, a biconcave negative lens L3, and a biconvex positive lens L4.

The lens unit Gr includes a biconvex positive lens L5, a biconcave negative lens L6, a positive meniscus lens L7 having a convex surface directed toward an image side, and a 50 negative meniscus lens L8 having a convex surface directed toward the object side.

The aperture stop S is positioned on the object side of the biconvex positive lens L5, and on the object side of a vertex of the object-side surface of the biconvex positive lens L5.

An aspheric surface is provided to both surfaces of all the lenses from the lens L1 to the lens L8.

The optical system according to the example 7 does not include a pair of lenses which satisfies conditional expressions (1), (2), and (3).

In some of the following examples, a diffractive optical element is used. The diffractive optical element used here is an optical element as described in Japanese Patent Publication No. 3717555 in which, at least two layers of mutually different optical materials are laminated and a relief pattern is 65 formed at an interface thereof, and a diffraction efficiency is made higher in a wide wavelength region. However, the dif72

fractive optical element to be used in the optical element of the examples is not restricted to such diffractive optical element, and may be a diffractive optical element described in Japanese Patent Application Laid-open Publication No. 2003-215457 and Japanese Patent Application Laid-open publication No. Hei 11-133305.

Next, an optical system according to an example 8 will be described below. FIG. 15A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 8. Moreover, FIG. 15B, FIG. 15C, FIG. 15D, and FIG. 15E are aberration diagrams of the optical system according to the example 8.

In the aberration diagrams shown in FIG. 15B, FIG. 15C, FIG. 15D, and FIG. 15E, 'FIY' denotes the maximum image height. Symbols in the aberration diagrams are same even in examples that will be described later. Moreover, in aberration diagrams of examples from the example 8 to an example 96, four aberration diagrams in order from left show a spherical aberration (SA), an astigmatism (AS), a distortion (DT), and a chromatic aberration of magnification (CC).

The optical system according to the example 8, as shown in FIG. 15A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. In the examples from the example 8 to the example 96, in lens cross-sectional views, S denotes a stop, C denotes a cover glass, and I denotes an image pickup surface of an image pickup element.

The first lens unit G1 includes a biconvex positive lens L1, 30 a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens FIG. 14B, FIG. 14C, and FIG. 14D are aberration diagrams of 35 L5 having a convex surface directed toward an image side, a positive meniscus lens L6 having a convex surface directed toward the image side, a positive meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, and a biconcave negative lens L9. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L9.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to seven surfaces namely, a surface on the image side of the positive meniscus lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the biconvex positive lens L8, and both surfaces of the biconcave negative lens L9.

Next, an optical system according to an example 9 will be described below. FIG. 16A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 9. Moreover, FIG. 16B, FIG. **16**C, FIG. **16**D, and FIG. **16**E are aberration diagrams of the 55 optical system according to the example 9.

The optical system according to the example 9, as shown in FIG. 16A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward an image side, a positive meniscus lens L7 having a convex surface directed

toward the image side, a biconvex positive lens L8, a biconvex positive lens L9, and a biconcave negative lens L10. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to nine surfaces namely, both surfaces of the biconcave negative lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex positive lens L9, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 10 will be described below. FIG. 17A is a cross-sectional view along an 15 optical axis showing an optical arrangement of the optical system according to the example 10. Moreover, FIG. 17B, FIG. 17C, FIG. 17D, and FIG. 17E are aberration diagrams of the optical system according to the example 10.

The optical system according to the example 10, as shown 20 in FIG. 17A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed 25 toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward an image side, a 30 positive meniscus lens L6 having a convex surface directed toward the image side, a biconvex positive lens L7, a biconcave negative lens L8, a biconvex positive lens L9, and a negative meniscus lens L10 having a convex surface directed toward the image side. The negative meniscus lens L5 and the 35 positive meniscus lens L6 are cemented. Moreover the biconvex positive lens L7 and the biconcave negative lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L10.

The aperture stop S is disposed between the biconcave 40 negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to five surfaces namely, a surface on the image side of the positive meniscus lens L2, both surfaces of the biconvex positive lens L9, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 11 will be described below. FIG. **18**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 11. Moreover, FIG. **18**B, FIG. **18**C, FIG. **18**D, and FIG. **18**E are aberration diagrams of 50 the optical system according to the example 11.

The optical system according to the example 11, as shown in FIG. **18**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 55

The first lens unit G1 includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a biconvex positive lens L7, a biconvex positive lens L8, a biconcave negative lens L9, and a biconcave negative lens L10. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. Moreover, the

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biconvex positive lens L8 and the biconcave negative lens L9 are cemented. A predetermined lens unit includes the biconcave negative lens L10.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to five surfaces namely, a surface on an image side of the positive meniscus lens L2, both surfaces of the biconvex positive lens L7, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 12 will be described below. FIG. 19A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 12. Moreover, FIG. 19B, FIG. 19C, FIG. 19D, and FIG. 19E are aberration diagrams of the optical system according to the example 12.

The optical system according to the example 12, as shown in FIG. 19A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a positive meniscus lens L10 having a convex surface directed toward the object side, and a biconcave negative lens L11. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 10 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 13 will be described below. FIG. **20**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 13. Moreover, FIG. **20**B, FIG. **20**C, FIG. **20**D, and FIG. **20**E are aberration diagrams of the optical system according to the example 13.

The optical system according to the example 13, as shown in FIG. **20**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconvex positive lens L7, a biconcave negative lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, a positive meniscus lens L10 having a convex surface directed toward the object side, and a biconcave negative lens L11. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconvex positive lens L7.

An aspheric surface is provided to 10 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 14 will be described below. FIG. 21A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 14. Moreover, FIG. 21B, FIG. 21C, FIG. 21D, and FIG. 21E are aberration diagrams of the optical system according to the example 14.

The optical system according to the example 14, as shown in FIG. 21A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a $_{20}$ biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a 25 biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, and a biconcave negative lens L10. A predetermined lens unit includes the biconcave negative lens L10.

The aperture stop S is disposed between the biconcave 30 negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 10 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 15 will be described below. FIG. 22A is a cross-sectional view along an 40 optical axis showing an optical arrangement of the optical system according to the example 15. Moreover, FIG. 22B, FIG. 22C, FIG. 22D, and FIG. 22E are aberration diagrams of the optical system according to the example 15.

The optical system according to the example 15, as shown 45 in FIG. 22A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward the object side, a 50 biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens 55 L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconcave negative lens L10, and a biconcave negative lens L11. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 11 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on an 65 image side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex

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positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 16 will be described below. FIG. 23A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 16. Moreover, FIG. 23B, FIG. 23C, FIG. 23D, and FIG. 23E are aberration diagrams of the optical system according to the example 16.

The optical system according to the example 16, as shown in FIG. 23A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward the object side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconvex positive lens L9, and a biconcave negative lens L10. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes a biconcave negative lens L10.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to nine surfaces namely, both surfaces of the positive meniscus lens L1, a surface on an image side of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex positive lens L9, and both surfaces of the biconcave negative lens L10.

Next, an optical system according to an example 17 will be described below. FIG. 24A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 17. Moreover, FIG. 24B, FIG. 24C, FIG. 24D, and FIG. 24E are aberration diagrams of the optical system according to the example 17.

The optical system according to the example 17, as shown in FIG. 24A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconvex positive lens L2, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward an image side, a positive meniscus lens L6 having a convex surface directed toward the image side, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, and a biconcave negative lens L9. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes a biconcave negative lens L9.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to seven surfaces namely, a surface on the image side of the biconvex positive lens L2, both surfaces of the biconvex positive lens L7, both surfaces of the positive meniscus lens L8, and both surfaces of the biconcave negative lens L9.

Next, an optical system according to an example 18 will be described below. FIG. 25A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 18. Moreover, FIG. 25B,

FIG. 25C, FIG. 25D, and FIG. 25E are aberration diagrams of the optical system according to the example 18.

The optical system according to the example 18, as shown in FIG. 25A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 5 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 10 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a biconvex positive lens L7, a positive 15 meniscus lens L8 having a convex surface directed toward an image side, a biconcave negative lens L9, and a negative meniscus lens L10 having a convex surface directed toward the image side. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens 20 unit includes the biconcave negative lens L9 and the negative meniscus lens L10.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to five surfaces namely, a 25 surface on the image side of the positive meniscus lens L2, both surfaces of the biconvex positive lens L7, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 19 will be described below. FIG. 26A is a cross-sectional view along an 30 optical axis showing an optical arrangement of the optical system according to the example 19. Moreover, FIG. 26B, FIG. 26C, FIG. 26D, and FIG. 26E are aberration diagrams of the optical system according to the example 19.

The optical system according to the example 19, as shown 35 in FIG. 26A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a diffractive optical element DL, a biconvex positive lens L1, a positive meniscus lens L2 40 having a convex surface directed toward the object side, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens 45 L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a negative meniscus lens L8 having a convex surface directed toward an 50 image side, a biconvex positive lens L9, a biconcave negative lens L10, and a biconcave negative lens L11. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side and a negative meniscus lens having a tern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to 12 surfaces namely, a surface on the object side of the biconvex positive lens L1, a 78

surface on the image side of the positive meniscus lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the negative meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens

Next, an optical system according to an example 20 will be described below. FIG. 27A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 20. Moreover, FIG. 27B, FIG. 27C, FIG. 27D, and FIG. 27E are aberration diagrams of the optical system according to the example 20.

The optical system according to the example 20, as shown in FIG. 27A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward an image side, and a negative meniscus lens L12 having a convex surface directed toward the image side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11 and the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 21 will be described below. FIG. 28A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 21. Moreover, FIG. 28B, FIG. 28C, FIG. 28D, and FIG. 28E are aberration diagrams of the optical system according to the example 21.

The optical system according to the example 21, as shown in FIG. 28A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed 55 toward the object side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens convex surface directed toward the object side. A relief pat- 60 L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a positive meniscus lens L11 having a convex surface directed toward the object side, a biconcave negative lens L12, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the positive meniscus

lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the biconvex positive lens L1, both surfaces of the negative meniscus lens L2, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 22 will be 15 described below. FIG. **29**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 22. Moreover, FIG. **29**B, FIG. **29**C, FIG. **29**D, and FIG. **29**E are aberration diagrams of the optical system according to the example 22.

The optical system according to the example 22, as shown in FIG. **29**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 25 having a convex surface directed toward the object side, a negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave 30 negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed 35 toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens L13 having a convex surface directed toward an image side. The negative meniscus lens L7 and the positive meniscus lens L8 40 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 14 surfaces namely, both 45 surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 23 will be described below. FIG. **30**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 55 system according to the example 23. Moreover, FIG. **30**B, FIG. **30**C, FIG. **30**D, and FIG. **30**E are aberration diagrams of the optical system according to the example 23.

The optical system according to the example 23, as shown in FIG. 30A, includes a first lens unit G1 having a positive 60 refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward the object side, a positive meniscus lens L2 having a convex surface directed 65 toward the object side, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex

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positive lens L4, a biconvex positive lens L5, a biconvex positive lens L6, and a biconcave negative lens L7. The negative meniscus lens L1 and the positive meniscus lens L2 are cemented. Moreover, the biconvex positive lens L6 and the biconcave negative lens L7 are cemented.

The second lens unit G2 includes a negative meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconcave negative lens L11, a biconvex positive lens L12, a biconcave negative lens L13, and a negative meniscus lens L14 having a convex surface directed toward an image side. The negative meniscus lens L8 and the positive meniscus lens L9 are cemented. A predetermined lens unit includes the biconcave negative lens L13 and the negative meniscus lens L14.

The aperture stop S is disposed between the biconcave negative lens L7 and the negative meniscus lens L8.

An aspheric surface is provided to 12 surfaces namely, a surface on the object side of the biconvex positive lens L4, a surface on the image side of the biconvex positive lens L5, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconcave negative lens L13, and both surfaces of the negative meniscus lens L14.

Next, an optical system according to an example 24 will be described below. FIG. 31A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 24. Moreover, FIG. 31B, FIG. 31C, FIG. 31D, and FIG. 31E are aberration diagrams of the optical system according to the example 24.

The optical system according to the example 24, as shown in FIG. 31A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens L13 having a convex surface directed toward the image side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 25 will be described below. FIG. 32A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 25. Moreover, FIG. 32B, FIG. 32C, FIG. 32D, and FIG. 32E are aberration diagrams of the optical system according to the example 25.

The optical system according to the example 25, as shown in FIG. 32A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a biconcave negative lens L13. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermine lens unit includes the biconcave negative lens L12 and the biconcave negative lens L13. 20

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object of the biconvex positive lens L3, a surface on the image 25 side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 26 will be described below. FIG. 33A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 26. Moreover, FIG. 33B, FIG. 33C, FIG. 33D, and FIG. 33E are aberration diagrams of 35 the optical system according to the example 26.

The optical system according to the example 26, as shown in FIG. 33A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an object side, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a negative meniscus lens L6 having a convex surface directed toward the image side. The positive meniscus lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a 50 positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens L13 having a 55 convex surface directed toward the image side. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus L13.

The aperture stop S is disposed between the negative 60 meniscus lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of 65 the positive meniscus lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens

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L11, both surfaces of the biconcave negative lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 27 will be described below. FIG. 34A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 27. Moreover, FIG. 34B, FIG. 34C, FIG. 34D, and FIG. 34E are aberration diagrams of the optical system according to the example 27.

The optical system according to the example 27, as shown in FIG. **34**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex surface directed toward the image side. The positive meniscus lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward an object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconcave negative lens L9, a biconvex positive lens L10, a biconcave negative lens L11, and a negative meniscus lens L12 having a convex surface directed toward the image side. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the negative meniscus lens L12.

The aperture stop S is disposed between the negative meniscus lens $\rm L5$ and the negative meniscus lens $\rm L6$.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 28 will be described below. FIG. 35A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 28. Moreover, FIG. 35B, FIG. 35C, FIG. 35D, and FIG. 35E are aberration diagrams of the optical system according to the example 28.

The optical system according to the example 28, as shown in FIG. **35**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex surface directed toward the image side. The positive meniscus lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L6 and the biconvex positive lens

L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12

The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the positive meniscus lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 29 will be described below. FIG. **36**A is a cross-sectional view along an 15 optical axis showing an optical arrangement of the optical system according to the example 29. Moreover, FIG. **36**B, FIG. **36**C, FIG. **36**D, and FIG. **36**E are aberration diagrams of the optical system according to the example 29.

The optical system according to the example 29, as shown 20 in FIG. **36**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a 25 positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex surface directed toward the image side. The positive meniscus 30 lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a negative meniscus lens L9 having a convex surface directed toward the image side, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L0 L12.

The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 45 object side of the positive meniscus lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and 50 both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 30 will be described below. FIG. 37A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 30. Moreover, FIG. 37B, 55 FIG. 37C, FIG. 37D, and FIG. 37E are aberration diagrams of the optical system according to the example 30.

The optical system according to the example 30, as shown in FIG. 37A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 60 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive 65 meniscus lens L4 having a convex surface directed toward an image side, and a negative meniscus lens L5 having a convex

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surface directed toward the image side. The positive meniscus lens L4 and the negative meniscus lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, and a biconcave negative lens L11. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the positive meniscus lens L2, a surface on the image side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 31 will be described below. FIG. 38A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 31. Moreover, FIG. 38B, FIG. 38C, FIG. 38D, and FIG. 38E are aberration diagrams of the optical system according to the example 31.

The optical system according to the example 31, as shown in FIG. 38A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconcave negative lens L11, and a positive meniscus lens L12 having a convex surface directed toward the object side. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the positive meniscus lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the positive meniscus lens L2, a surface on an image side of the positive meniscus lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the positive meniscus lens L12.

Next, an optical system according to an example 32 will be described below. FIG. **39**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 32. Moreover, FIG. **39**B, FIG. **39**C, FIG. **39**D, and FIG. **39**E are aberration diagrams of the optical system according to the example 32.

The optical system according to the example 32, as shown in FIG. 39A, includes a first lens unit G1 having a positive

refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a positive meniscus lens L2 having a convex surface directed toward the object side, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex 15 positive lens L9, a biconcave negative lens L10, and a positive meniscus lens L11 having a convex surface directed toward an image side. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the positive 20 meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 25 object side of the positive meniscus lens L2, a surface on the image side of the positive meniscus lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the positive meniscus lens L11.

Next, an optical system according to an example 33 will be described below. FIG. **40**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 33. Moreover, FIG. **40**B, FIG. **40**C, FIG. **40**D, and FIG. **40**E are aberration diagrams of 35 the optical system according to the example 33.

The optical system according to the example 33, as shown in FIG. **40**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave 45 negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed 50 toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermine lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an 60 image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 34 will be 65 described below. FIG. 41A is a cross-sectional view along an optical axis showing an optical arrangement of the optical

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system according to the example 34. Moreover, FIG. 41B, FIG. 41C, FIG. 41D, and FIG. 41E are aberration diagrams of the optical system according to the example 34.

The optical system according to the example 34, as shown in FIG. 41A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a biconcave negative lens L12, and a biconcave negative lens L13. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 15 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconvex negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconvex negative lens L12, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 35 will be described below. FIG. 42A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 35. Moreover, FIG. 42B, FIG. 42C, FIG. 42D, and FIG. 42E are aberration diagrams of the optical system according to the example 35.

The optical system according to the example 35, as shown in FIG. **42**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 36 will be described below. FIG. **43**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 36. Moreover, FIG. **43**B, FIG. **43**C, FIG. **43**D, and FIG. **43**E are aberration diagrams of 5 the optical system according to the example 36.

The optical system according to the example 36, as shown in FIG. 43A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a biconvex positive lens L10, and a biconcave negative lens L11. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 11 surfaces namely, a 25 surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 37 will be described below. FIG. **44**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 37. Moreover, FIG. **44**B, FIG. **44**C, FIG. **44**D, and FIG. **44**E are aberration diagrams of the optical system according to the example 37.

The optical system according to the example 37, as shown in FIG. 44A, includes a first lens unit G1 having a positive 40 refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a 45 biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a 50 biconvex positive lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the 55 biconcave negative lens L12 and the positive meniscus lens L13

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a 60 surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

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Next, an optical system according to an example 38 will be described below. FIG. **45**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 38. Moreover, FIG. **45**B, FIG. **45**C, FIG. **45**D, and FIG. **45**E are aberration diagrams of the optical system according to the example 38.

The optical system according to the example 38, as shown in FIG. **45**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. The predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the positive meniscus lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12

Next, an optical system according to an example 39 will be described below. FIG. **46**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 39. Moreover, FIG. **46**B, FIG. **46**C, FIG. **46**D, and FIG. **46**E are aberration diagrams of the optical system according to the example 39.

The optical system according to the example 39, as shown in FIG. **46**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a negative meniscus lens L6 having a convex surface directed toward an image side. The biconvex positive lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a biconvex positive lens L7, a biconcave negative lens L8, a negative meniscus lens L9 having a convex surface directed toward the image side, a biconvex positive lens L10, and a biconcave negative lens L11. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the negative meniscus lens L6 and the biconvex positive lens L7.

An aspheric surface is provided to 10 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on an object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 40 will be described below. FIG. **47**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 40. Moreover, FIG. **47**B, FIG. **47**C, FIG. **47**D, and FIG. **47**E are aberration diagrams of 5 the optical system according to the example 40.

The optical system according to the example 40, as shown in FIG. 47A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L1 and the biconcave negative lens L2 are cemented. Moreover, 15 the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconvex positive lens L7, a biconcave negative lens L8, a negative meniscus lens L9 having a convex surface directed toward an image side, a 20 biconvex positive lens L10, and a biconcave negative lens L11. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The aperture stop S is disposed between the biconcave 25 negative lens L6 and the biconvex positive lens L7.

An aspheric surface is provided to 11 surfaces namely, a surface on an object side of the biconvex positive lens L1, a cemented surface of the biconvex positive lens L1 and the biconcave negative lens L2, a surface on the image side of the biconvex positive lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 41 will be described below. FIG. **48**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 41. Moreover, FIG. **48**B, FIG. **48**C, FIG. **48**D, and FIG. **48**E are aberration diagrams of 40 the optical system according to the example 41.

The optical system according to the example 41, as shown in FIG. **48**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an object side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The negative meniscus lens L1 50 and the biconvex positive lens L2 are cemented. Moreover, the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a 55 positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward the object side, a negative 60 meniscus lens L12 having a convex surface directed toward an image side, and a biconcave negative lens L13. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

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An aspheric surface is provided to eight surfaces namely, both surfaces of the biconcave negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 42 will be described below. FIG. **49**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 42. Moreover, FIG. **49**B, FIG. **49**C, FIG. **49**D, and FIG. **49**E are aberration diagrams of the optical system according to the example 42.

The optical system according to the example 42, as shown in FIG. **49**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an image side, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L1 and the negative meniscus lens L2 are cemented. Moreover, the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward an object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the object side, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a negative meniscus lens L12 having a convex surface directed toward the object side, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to eight surfaces namely, both surfaces of the biconcave negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 43 will be described below. FIG. **50**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 43. Moreover, FIG. **50**B, FIG. **50**C, FIG. **50**D, and FIG. **50**E are aberration diagrams of the optical system according to the example 43.

The optical system according to the example 43, as shown in FIG. **50**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on 5 the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 44 will be described below. FIG. **51**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 44. Moreover, FIG. **51**B, 15 FIG. **51**C, FIG. **51**D, and FIG. **51**E are aberration diagrams of the optical system according to the example 44.

The optical system according to the example 44, as shown in FIG. **51**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 20 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 25 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed 30 toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on 40 the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 45 will be described below. FIG. **52**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 45. Moreover, FIG. **52**B, 50 FIG. **52**C, FIG. **52**D, and FIG. **52**E are aberration diagrams of the optical system according to the example 45.

The optical system according to the example 45, as shown in FIG. **52**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 55 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 60 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed 65 toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7

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and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 46 will be described below. FIG. **53**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 46. Moreover, FIG. **53**B, FIG. **53**C, FIG. **53**D, and FIG. **53**E are aberration diagrams of the optical system according to the example 46.

The optical system according to the example 46, as shown in FIG. **53**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 47 will be described below. FIG. **54**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 47. Moreover, FIG. **54**B, FIG. **54**C, FIG. **54**D, and FIG. **54**E are aberration diagrams of the optical system according to the example 47.

The optical system according to the example 47, as shown in FIG. **54**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward an object side, a biconvex positive lens L9, a

biconvex positive lens L10, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on an image side of the biconvex positive lens L1, both surfaces of the biconcave negative lens L2, a surface on 10 the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens 15

Next, an optical system according to an example 48 will be described below. FIG. 55A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 48. Moreover, FIG. 55B, 20 FIG. 55C, FIG. 55D, and FIG. 55E are aberration diagrams of the optical system according to the example 48.

The optical system according to the example 48, as shown in FIG. 55A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 25 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having 30 a convex surface directed toward an object side, and a negative meniscus lens L6 having a convex surface directed toward the object side. The positive meniscus lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens 35 L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconcave negative lens L11, and a biconcave negative lens L12. The biconcave negative lens L7 40 a biconcave negative lens L2, a biconvex positive lens L3, a and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the biconcave negative lens L12.

The aperture stop S is disposed between the negative meniscus lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on the image side of the positive meniscus lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces 50 of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 49 will be 55 described below. FIG. 56A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 49. Moreover, FIG. **56**B, FIG. 56C, FIG. 56D, and FIG. 56E are aberration diagrams of the optical system according to the example 49.

The optical system according to the example 49, as shown in FIG. 56A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 65 having a convex surface directed toward an image side, a biconcave negative lens L2, a biconvex positive lens L3, a

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biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an object side, and a negative meniscus lens L6 having a convex surface directed toward the object side. The positive meniscus lens L5 and the negative meniscus lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a biconcave negative lens L11, and a negative meniscus lens L12 having a convex surface directed toward the image side. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the negative meniscus lens L12.

The aperture stop S is disposed between the negative meniscus lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 13 surfaces namely, a surface on the image side of the positive meniscus lens L1, both surfaces of the biconcave negative lens L2, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconcave negative lens L11, and both surfaces of the negative meniscus lens L12

Next, an optical system according to an example 50 will be described below. FIG. 57A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 50. Moreover, FIG. 57B, FIG. 57C, FIG. 57D, and FIG. 57E are aberration diagrams of the optical system according to the example 50.

The optical system according to the example 50, as shown in FIG. 57A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave 60 negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 51 will be described below. FIG. **58**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 51. Moreover, FIG. 58B, FIG. 58C, FIG. 58D, and FIG. 58E are aberration diagrams of the optical system according to the example 51.

The optical system according to the example 51, as shown in FIG. 58A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, 5 a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave 20 negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of 25 the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 52 will be described below. FIG. 59A is a cross-sectional view along an 30 optical axis showing an optical arrangement of the optical system according to the example 52. Moreover, FIG. 59B, FIG. 59C, FIG. 59D, and FIG. 59E are aberration diagrams of the optical system according to the example 52.

The optical system according to the example 52, as shown 35 in FIG. 59A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens 45 L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 50 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both 55 surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens 60 L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 53 will be described below. FIG. 60A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 53. Moreover, FIG. 60B, 65 FIG. 60C, FIG. 60D, and FIG. 60E are aberration diagrams of the optical system according to the example 53.

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The optical system according to the example 53, as shown in FIG. 60A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward an object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes a biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

Next, an optical system according to an example 54 will be described below. FIG. 61A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 54. Moreover, FIG. 61B, FIG. 6C, FIG. 61D, and FIG. 61E are aberration diagrams of the optical system according to the example 54.

The optical system according to the example 54, as shown in FIG. 61A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a biconcave negative lens L2, a biconvex positive lens L3, a 40 a biconcave negative lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

> The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, and a biconcave negative lens L12. The negative meniscus lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

> The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

> An aspheric surface is provided to 12 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, a surface on an image side of the positive meniscus lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the biconcave negative lens L12.

> Next, an optical system according to an example 55 will be described below. FIG. **62**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 55. Moreover, FIG. 62B, FIG. 62C, FIG. 62D, and FIG. 62E are aberration diagrams of the optical system according to the example 55.

The optical system according to the example 55, as shown in FIG. **62**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 5 having a convex surface directed toward an object side, a biconvex positive lens L2, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are 10 cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconcave negative lens L9, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward an image side, and a biconcave negative lens L12. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 25 object side of the biconvex positive lens L2, a surface on the image side of the positive meniscus lens L3, a surface on the object side of the biconvex positive lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens 30 L11, an a surface on the image side of the biconcave negative lens L12.

Next, an optical system according to an example 56 will be described below. FIG. **63**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 35 system according to the example 56. Moreover, FIG. **63**B, FIG. **63**C, FIG. **63**D, and FIG. **63**E are aberration diagrams of the optical system according to the example 56.

The optical system according to the example 56, as shown in FIG. **63**A, includes a first lens unit G1 having a positive 40 refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a diffractive optical element DL, a biconvex positive lens L1, a positive meniscus lens L2 having a convex surface directed toward an object side, a 45 biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a 50 positive meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a negative meniscus lens L8 having a convex surface directed toward an image side, a biconvex positive lens L9, a biconcave negative 55 lens L10, and a biconcave negative lens L11. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive 60 power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side and a negative meniscus lens having a convex surface directed toward the object side. A relief pattern is formed at an interface of the positive meniscus lens and 65 the negative meniscus lens, and the interface is let to be a diffractive surface.

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The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to 12 surfaces namely, a surface on the object side of the biconvex positive lens L1, a surface on the image side of the positive meniscus lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the negative meniscus lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 57 will be described below. FIG. **64**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 57. Moreover, FIG. **64**B, FIG. **64**C, FIG. **64**D, and FIG. **64**E are aberration diagrams of the optical system according to the example 57.

The optical system according to the example 57, as shown in FIG. **64**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a biconvex positive lens L2, a diffractive optical element DL, a biconvex positive lens L3, and a biconcave negative lens L4. The biconvex positive lens L3 and the biconcave negative lens L4 are cemented.

The second lens unit G2 includes a negative meniscus lens L5 having a convex surface directed toward the object side, a positive meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconcave negative lens L9, and a negative meniscus lens L10 having a convex surface directed toward the object side. The negative meniscus lens L5 and the positive meniscus lens L6 are cemented. A predetermined lens unit includes the biconcave negative lens L9 and the negative meniscus lens L10.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side and a negative meniscus lens having a convex surface directed toward the object side. A relief pattern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L4 and the negative meniscus lens L5.

An aspheric surface is provided to 11 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L2, both surfaces of the positive meniscus lens L7, both surfaces of the biconvex positive lens L8, both surfaces of the biconcave negative lens L9, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 58 will be described below. FIG. **65**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 58. Moreover, FIG. **65**B, FIG. **65**C, FIG. **65**D, and FIG. **65**E are aberration diagrams of the optical system according to the example 58.

The optical system according to the example 58, as shown in FIG. **65**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a positive

meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a biconcave negative lens L10, a diffractive optical element DL, and a biconcave negative lens L11. The biconcave negative lens L7 and the positive meniscus lens L8 are cemented. A predetermined lens unit includes a biconcave negative lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a biconvex positive lens and a negative meniscus lens having 15 a convex surface directed toward an image side. A relief pattern is formed at an interface of the biconvex positive lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave 20 negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 10 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the object side of the biconvex positive lens L3, a surface on the image side of the positive meniscus lens L4, both surfaces of 25 the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 59 will be described below. FIG. **66**A is a cross-sectional view along an 30 optical axis showing an optical arrangement of the optical system according to the example 59. Moreover, FIG. **66**B, FIG. **66**C, FIG. **66**D, and FIG. **66**E are aberration diagrams of the optical system according to the example 59.

The optical system according to the example 59, as shown 35 in FIG. **66**A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a negative refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an object side, a 40 negative meniscus lens L2 having a convex surface directed toward the object side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a diffractive optical element DL, a negative meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, and a biconcave negative lens L11. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The diffractive optical element DL has a positive refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward the object side, and a negative meniscus lens having a convex surface directed toward the object side. A relief pattern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a 60 diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 12 surfaces namely, both surfaces of the positive meniscus lens L1, a surface on the 65 object side of the biconvex positive lens L3, a surface on an image side of the biconvex positive lens L4, both surfaces of

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the diffractive optical element DL, both surfaces of the negative meniscus lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 60 will be described below. FIG. **67**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 60. Moreover, FIG. **67**B, FIG. **67**C, FIG. **67**D, and FIG. **67**E are aberration diagrams of the optical system according to the example 60.

The optical system according to the example 60, as shown in FIG. 67A, includes a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an object side, a biconvex positive lens L3, a diffractive optical element DL, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a positive meniscus lens L7 having a convex surface directed toward the object side, a positive meniscus lens L8 having a convex surface directed toward the object side, a biconcave negative lens L9, a biconvex positive lens L10, and a biconcave negative lens L11. The negative meniscus lens L6 and the positive meniscus lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11.

The diffractive optical element DL has a negative refractive power as a whole. The diffractive optical element DL includes a positive meniscus lens having a convex surface directed toward an object side and a negative meniscus lens having a convex surface directed toward the image side. A relief pattern is formed at an interface of the positive meniscus lens and the negative meniscus lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6.

An aspheric surface is provided to 11 surfaces namely, both surfaces of the biconvex positive lens L1, a surface on the object side of the biconvex positive lens L3, both surfaces of the positive meniscus lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the biconcave negative lens L11.

Next, an optical system according to an example 61 will be described below. FIG. **68**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 61. Moreover, FIG. **68**B, FIG. **68**C, FIG. **68**D, and FIG. **68**E are aberration diagrams of the optical system according to the example 61.

The optical system according to the example 61, as shown in FIG. **68**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a

negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 62 will be described below. FIG. **69**A is a cross-sectional view along an 20 optical axis showing an optical arrangement of the optical system according to the example 62. Moreover, FIG. **69**B, FIG. **69**C, FIG. **69**D, and FIG. **69**E are aberration diagrams of the optical system according to the example 62.

The optical system according to the example 62, as shown 25 in FIG. **69**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 30 biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a 40 negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative 45 meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the 50 biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative 55 meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 63 will be described below. FIG. **70**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical 60 system according to the example 63. Moreover, FIG. **70**B, FIG. **70**C, FIG. **70**D, and FIG. **70**E are aberration diagrams of the optical system according to the example 63.

The optical system according to the example 63, as shown in FIG. **70**A, includes in order from an object side, a first lens 65 unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

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The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the image side, a negative meniscus lens L10 having a convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L10 and the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the negative meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 64 will be described below. FIG. 71A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 64. Moreover, FIG. 71B, FIG. 71C, FIG. 71D, and FIG. 71E are aberration diagrams of the optical system according to the example 64.

The optical system according to the example 64, as shown in FIG. 71A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward the image side, a negative meniscus lens L10 having a convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L10 and the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L9, both surfaces of the negative meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 65 will be described below. FIG. **72**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 65. Moreover, FIG. **72**B, FIG. **72**C, FIG. **72**D, and FIG. **72**E are aberration diagrams of the optical system according to the example 65.

The optical system according to the example 65, as shown in FIG. 72A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 5 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 20 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both 25 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the 30 positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 66 will be described below. FIG. 73A is a cross-sectional view along an 35 negative lens L6 and the biconcave negative lens L7. optical axis showing an optical arrangement of the optical system according to the example 66. Moreover, FIG. 73B, FIG. 73C, FIG. 73D, and FIG. 73E are aberration diagrams of the optical system according to the example 66.

The optical system according to the example 66, as shown 40 in FIG. 73A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 45 biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a 55 negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative 60 meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the 65 biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens

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L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 67 will be described below. FIG. 74A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 67. Moreover, FIG. 74B, FIG. 74C, FIG. 74D, and FIG. 74E are aberration diagrams of the optical system according to the example 67.

The optical system according to the example 67, as shown in FIG. 74A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the object side, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, a negative meniscus lens L12 having a convex surface directed toward the image side, and a negative meniscus lens L13 having a convex surface directed toward the object side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave

An aspheric surface is provided to 18 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 68 will be described below. FIG. 75A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 68. Moreover, FIG. 75B, FIG. 75C, FIG. 75D, and FIG. 75E are aberration diagrams of the optical system according to the example 68.

The optical system according to the example 68, as shown in FIG. 75A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a biconcave negative lens L6, a biconvex positive lens L7, and a negative meniscus lens L8 having a convex surface directed toward an image side. The biconvex positive lens L7 and the negative meniscus lens L8 are cemented.

The second lens unit G2 includes a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the image side, a biconcave negative lens L11, a biconvex positive lens L12, a positive meniscus lens L13 having a convex surface directed toward the object side, a biconvex positive lens L14, a negative meniscus lens L15

having a convex surface directed toward the object side, a negative meniscus lens L16 having a convex surface directed toward the image side, and a biconcave negative lens L17. The positive meniscus lens L10, the biconcave negative lens L11, and the biconvex positive lens L12 are cemented. A 5 predetermined lens unit includes the negative meniscus lens L16 and the biconcave negative lens L17.

The aperture stop S is disposed between the negative meniscus lens L8 and the biconvex positive lens L9. More elaborately, the aperture stop is disposed between a vertex of an object-side surface of the biconvex positive lens L9 and a vertex of an image-side surface of the biconvex positive lens

An aspheric surface is provided to 24 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of 15 the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the cus lens L13, both surfaces of the biconvex positive lens L14, both surfaces of the negative meniscus lens L15, both surfaces of the negative meniscus lens L16, and both surfaces of the biconcave negative lens L17.

Next, an optical system according to an example 69 will be 25 described below. FIG. 76A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 69. Moreover, FIG. 76B, FIG. 76C, FIG. 76D, and FIG. 76E are aberration diagrams of the optical system according to the example 69.

The optical system according to the example 69, as shown in FIG. 76A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens 35 L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a biconcave negative lens L6, a biconvex positive lens L7, and a biconcave negative lens L8. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented.

The second lens unit G2 includes a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward an image side, a biconcave negative lens L11, a biconvex positive lens L12, a positive meniscus lens L13 having a convex surface directed toward the object side, a 45 biconvex positive lens L14, a negative meniscus lens L15 having a convex surface directed toward the object side, a biconvex positive lens L16, and a biconcave negative lens L17. The positive meniscus lens L10, the biconcave negative lens L11, and the biconvex positive lens L12 are cemented. A 50 predetermined lens unit includes the biconcave negative lens L17.

The aperture stop S is disposed between the biconcave negative lens L8 and the biconvex positive lens L9. More elaborately, the aperture stop S is disposed between a vertex 55 L1, a biconvex positive lens L2, a biconvex positive lens L3, of an object-side surface of the biconvex positive lens L9 and a vertex of an image-side surface of the biconvex positive lens L9.

An aspheric surface is provided to 24 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of 60 the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L13, both surfaces of the biconvex positive lens L14, both surfaces of the negative meniscus lens L15, both sur106

faces of the biconvex positive lens L16, and both surfaces of the biconcave negative lens L17.

Next, an optical system according to an example 70 will be described below. FIG. 77A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 70. Moreover, FIG. 77B, FIG. 77C, FIG. 77D, and FIG. 77E are aberration diagrams of the optical system according to the example 70.

The optical system according to the example 70, as shown in FIG. 77A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a biconcave negative lens L6, a biconvex positive lens L7, and a biconcave negative lens L8. The biconvex positive lens L7 and the biconcave negative lens L8 are cemented.

The second lens unit G2 includes a biconvex positive lens biconvex positive lens L9, both surfaces of the positive menis- 20 L9, a positive meniscus lens L10 having a convex surface directed toward an image side, a biconcave negative lens L11, a biconvex positive lens L12, a positive meniscus lens L13 having a convex surface directed toward the object side, a biconvex positive lens L14, a negative meniscus lens L15 having a convex surface directed toward the object side, and a negative meniscus lens L16 having a convex surface directed toward the image side. The positive meniscus lens L10, the biconcave negative lens L11, and the biconvex positive lens L12 are cemented. A predetermined lens unit includes the negative meniscus lens L15 and the negative meniscus lens L16.

> The aperture stop S is disposed between the biconcave negative lens L8 and the biconvex positive lens L9.

> An aspheric surface is provided to 22 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the biconvex positive lens L9, both surfaces of the positive meniscus lens L13, both surfaces of the biconvex positive lens L14, both surfaces of the negative meniscus lens L15, and both surfaces of the negative meniscus lens L16.

> Next, an optical system according to an example 71 will be described below. FIG. 78A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 71. Moreover, FIG. 78B, FIG. 78C, FIG. 78D, and FIG. 78E are aberration diagrams of the optical system according to the example 71.

> The optical system according to the example 71, as shown in FIG. 78A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

> The first lens unit G1 includes a biconcave negative lens a biconvex positive lens L4, a biconcave negative lens L5, a biconvex positive lens L6, and a biconcave negative lens L7. The biconvex positive lens L6 and the biconcave negative lens L7 are cemented.

> The second lens unit G2 includes a biconvex positive lens L8, a positive meniscus lens L9 having a convex surface directed toward an image side, a biconcave negative lens L10, a biconvex positive lens L11, a positive meniscus lens L12 having a convex surface directed toward the object side, a biconvex positive lens L13, a negative meniscus lens L14 having a convex surface directed toward the object side, and a negative meniscus lens L15 having a convex surface

directed toward the image side. The positive meniscus lens L9, the biconcave negative lens L10, and the biconvex positive lens L11 are cemented. A predetermined lens unit includes the negative meniscus lens L14 and the negative meniscus lens L15.

The aperture stop S is disposed between the biconcave negative lens L7 and the biconvex positive lens L8. More elaborately, the aperture stop S is disposed between a vertex of an object-side surface of the biconvex positive lens L8 and a vertex of an image-side surface of the biconvex positive lens 10

An aspheric surface is provided to 20 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens 15 L4, both surfaces of the biconcave negative lens L5, both surfaces of the biconvex positive lens L8, both surfaces of the positive meniscus lens L12, both surfaces of the biconvex positive lens L13, both surfaces of the negative meniscus lens L14, and both surfaces of the negative meniscus lens L15.

Next, an optical system according to an example 72 will be described below. FIG. 79A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 72. Moreover, FIG. 79B, FIG. 79C, FIG. 79D, and FIG. 79E are aberration diagrams of 25 the optical system according to the example 72.

The optical system according to the example 72, as shown in FIG. 79A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 30

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The 35 positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a negative meniscus lens L9 having a convex surface directed 40 toward the image side, a positive meniscus lens L10 having a convex surface directed toward the image side, a biconvex positive lens L11, and a negative meniscus lens L12 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are 45 cemented. A predetermined lens unit includes the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 16 surfaces namely, both 50 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the positive meniscus lens L10, both surfaces of the biconvex positive lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 73 will be described below. FIG. 80A is a cross-sectional view along an system according to the example 73. Moreover, FIG. 80B, FIG. 80C, FIG. 80D, and FIG. 80E are aberration diagrams of the optical system according to the example 73.

The optical system according to the example 73, as shown in FIG. 80A, includes in order from an object side, a first lens 65 unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

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The first lens unit G1 includes a biconcave negative lens L1, a positive meniscus lens L2 having a convex surface directed toward an image side, a biconvex positive lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a negative meniscus lens L6 having a convex surface directed toward the image side, a positive meniscus lens L7 having a convex surface directed toward the image side, a biconcave negative lens L8, a biconvex positive lens L9, and a negative meniscus lens L10 having a convex surface directed toward the image side. The biconvex positive lens L9 and the negative meniscus lens L10 are cemented.

The second lens unit G2 includes a positive meniscus lens L11 having a convex surface directed toward the object side, a biconvex positive lens L12, a biconcave negative lens L13, a biconvex positive lens L14, a positive meniscus lens L15 having a convex surface directed toward the object side, a biconvex positive lens L16, a negative meniscus lens L17 having a convex surface directed toward the object side, a 20 positive meniscus lens L18 having a convex surface directed toward the image side, and a biconcave negative lens L19. The biconvex positive lens L12, the biconcave negative lens L13, and the biconvex positive lens L14 are cemented. A predetermined lens unit includes the biconcave negative lens

The aperture stop S is disposed between the negative meniscus lens L10 and the positive meniscus lens L11.

An aspheric surface is provided to 28 surfaces namely, both surfaces of the biconcave negative lens L1, both surfaces of the positive meniscus lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the negative meniscus lens L6, both surfaces of the positive meniscus lens L7, both surfaces of the biconcave negative lens L8, both surfaces of the positive meniscus lens L11, both surfaces of the positive meniscus lens L15, both surfaces of the biconvex positive lens L16, both surfaces of the negative meniscus lens L17, both surfaces of the positive meniscus lens L18, and both surfaces of the biconcave negative lens L19.

Next, an optical system according to an example 74 will be described below. FIG. 81A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 74. Moreover, FIG. 81B, FIG. 81C, FIG. 81D, and FIG. 81E are aberration diagrams of the optical system according to the example 74.

The optical system according to the example 74, as shown in FIG. 81A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the image side, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens optical axis showing an optical arrangement of the optical 60 L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconvex positive lens L10, a biconcave negative lens L11, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative 5 meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 75 will be described below. FIG. **82**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 75. Moreover, FIG. **82**B, 15 FIG. **82**C, FIG. **82**D, and FIG. **82**E are aberration diagrams of the optical system according to the example 75.

The optical system according to the example 75, as shown in FIG. **82**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 20 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed 25 toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, 30 a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, a negative meniscus lens L12 having a convex surface directed toward the image side, and a biconcave negative lens L13. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L12 and the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 18 surfaces namely, both 40 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, both surfaces of the 45 biconvex positive lens L11, both surfaces of the negative meniscus lens L12, and both surfaces of the biconcave negative lens L13.

Next, an optical system according to an example 76 will be described below. FIG. **83**A is a cross-sectional view along an 50 optical axis showing an optical arrangement of the optical system according to the example 76. Moreover, FIG. **83**B, FIG. **83**C, FIG. **83**D, and FIG. **83**E are aberration diagrams of the optical system according to the example 76.

The optical system according to the example 76, as shown 55 in FIG. 83A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 60 biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9,

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a biconvex positive lens L10, a biconcave negative lens L11, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 77 will be described below. FIG. **84**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 77. Moreover, FIG. **84**B, FIG. **84**C, FIG. **84**D, and FIG. **84**E are aberration diagrams of the optical system according to the example 77.

The optical system according to the example 77, as shown in FIG. **84**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward the image side, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 78 will be described below. FIG. **85**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 78. Moreover, FIG. **85**B, FIG. **85**C, FIG. **85**D, and FIG. **85**E are aberration diagrams of the optical system according to the example 78.

The optical system according to the example 78, as shown in FIG. **85**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a negative meniscus lens L3 having a convex surface directed toward the image side, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward the image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, 10 a biconvex positive lens L10, a negative meniscus lens L11 having a convex surface directed toward the image side, a biconvex positive lens L12, a negative meniscus lens L13 having a convex surface directed toward the image side, and a biconcave negative lens L14. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L13 and the biconcave negative lens L14.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 20 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the negative meniscus lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconvex positive lens L10, both surfaces of the negative meniscus lens L11, both surfaces of the biconvex positive lens L12, both surfaces of the negative meniscus lens L13, and both surfaces of the biconcave negative lens L14.

Next, an optical system according to an example 79 will be 30 described below. FIG. **86**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 79. Moreover, FIG. **86**B, FIG. **86**C, FIG. **86**D, and FIG. **86**E are aberration diagrams of the optical system according to the example 79.

The optical system according to the example 79, as shown in FIG. **86**A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, 40 a biconcave negative lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The positive meniscus lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, a biconcave negative lens L12, and a negative meniscus lens 50 L13 having a convex surface directed toward the image side. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the negative meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the biconvex positive lens L1, an object-side surface of the biconvex positive lens L3, an image-side surface of 60 the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the biconcave negative lens L12, an both surfaces of the negative meniscus lens L13.

Next, an optical system according to an example 80 will be described below. FIG. 87A is a cross-sectional view along an

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optical axis showing an optical arrangement of the optical system according to the example 80. Moreover, FIG. 87B, FIG. 87C, FIG. 87D, and FIG. 87E are aberration diagrams of the optical system according to the example 80.

The optical system according to the example 80, as shown in FIG. 87A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconcave negative lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a positive meniscus lens L11 having a convex surface directed toward the object side, a
 biconcave negative lens L12, and a biconcave negative lens L13. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 10 surfaces namely, an image-side surface of the negative meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, an object-side surface of the positive meniscus lens L11, and an image-side surface of the biconcave negative lens L13.

Next, an optical system according to an example 81 will be described below. FIG. **88**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 81. Moreover, FIG. **88**B, FIG. **88**C, FIG. **88**D, and FIG. **88**E are aberration diagrams of the optical system according to the example 81.

The optical system according to the example 81, as shown in FIG. 88A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a positive meniscus lens L10 having a convex surface directed toward the object side, a negative meniscus lens L11 having a convex surface directed toward the object side, a positive meniscus lens L12 having a convex surface directed toward the object side, and a biconcave negative lens L13. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 12 surfaces namely, an image-side surface of the negative meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the positive menis-

cus lens L10, both surfaces of the negative meniscus lens L11, an object-side surface of the positive meniscus lens L12, and an image-side surface of the biconcave negative lens L13.

Next, an optical system according to an example 82 will be described below. FIG. **89**A is a cross-sectional view along an 5 optical axis showing an optical arrangement of the optical system according to the example 82. Moreover, FIG. **89**B, FIG. **89**C, FIG. **89**D, and FIG. **89**E are aberration diagrams of the optical system according to the example 82.

The optical system according to the example 82, as shown 10 in FIG. 89A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 15 biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, and a biconcave negative lens L6. The biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a biconcave negative lens 20 L7, a biconvex positive lens L8, a biconvex positive lens L9, a biconcave negative lens L10, a positive meniscus lens L11 having a convex surface directed toward the object side, and a biconcave negative lens L12. The biconcave negative lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12.

The aperture stop S is disposed between the biconcave negative lens L6 and the biconcave negative lens L7.

An aspheric surface is provided to 10 surfaces namely, an image-side surface of the negative meniscus lens 11, an 30 object-side lens of the biconvex positive lens L2, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L9, both surfaces of the biconcave negative lens L10, an object-side surface of the positive meniscus lens L11, and an image-side surface of the biconcave negative lens L12.

Next, an optical system according to an example 83 will be described below. FIG. **90**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 83. Moreover, FIG. **90**B, 40 L5. FIG. **90**C, FIG. **90**D, and FIG. **90**E are aberration diagrams of the optical system according to the example 83.

The optical system according to the example 83, as shown in FIG. 90A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 45 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconcave negative lens L3, a biconvex positive lens L4, a biconvex positive lens L5, a 50 biconvex positive lens L6, and a biconcave negative lens L7. The biconvex positive lens L6 and the biconcave negative lens L7 are cemented.

The second lens unit G2 includes a biconcave negative lens L8, a biconvex positive lens L9, a biconvex positive lens L10, 55 a biconvex positive lens L11, a negative meniscus lens L12 having a convex surface directed toward the image side, a biconvex positive lens L13, a negative meniscus lens L14 having a convex surface directed toward the image side, and a biconcave negative lens L15. The biconcave negative lens L8 and the biconvex positive lens L9 are cemented. A predetermined lens unit includes the negative meniscus lens L14 and the biconcave negative lens L15.

The aperture stop S is disposed between the biconcave negative lens L7 and the biconcave negative lens L8.

An aspheric surface is provided to 22 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the

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biconvex positive lens L2, both surfaces of the biconcave negative lens L3, both surfaces of the biconvex positive lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconvex positive lens L10, both surfaces of the biconvex positive lens L11, both surfaces of the negative meniscus lens L12, both surfaces of the biconvex positive lens L13, both surfaces of the negative meniscus lens L14, and both surfaces of the biconcave negative lens L15.

Next, an optical system according to an example 84 will be described below. FIG. 91A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 84. Moreover, FIG. 91B, FIG. 91C, FIG. 91D, and FIG. 91E are aberration diagrams of the optical system according to the example 84.

The optical system according to the example 84, as shown in FIG. 91A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconvex positive lens L1, a negative meniscus lens L2 having a convex surface directed toward an image side, a positive meniscus lens L3 having a convex surface directed toward the image side, and a negative meniscus lens L4 having a convex surface directed toward the object side. The biconvex positive lens L1 and the negative meniscus lens L2 are cemented.

The second lens unit G2 includes a biconvex positive lens L5, a biconcave negative lens L6, a negative meniscus lens L7 having a convex surface directed toward the image side, a positive meniscus lens L8 having a convex surface directed toward the object side, a positive meniscus lens L9 having a convex surface directed toward the image side, and a negative meniscus lens L10 having a convex surface directed toward the object side. A predetermined lens unit includes the negative meniscus lens L10.

The aperture stop S is disposed between the negative meniscus lens L4 and the biconvex positive lens L5. More elaborately, the aperture stop S is disposed between a vertex of an object-side surface of the biconvex positive lens L5 and a vertex of an image-side surface of the biconvex positive lens L5.

An aspheric surface is provided to 16 surfaces namely, both surface of the positive meniscus lens L3, both surfaces of the negative meniscus lens L4, both surfaces of the biconvex positive lens L5, both surfaces of the biconcave negative lens L6, both surfaces of the negative meniscus lens L7, both surfaces of the positive meniscus lens L8, both surfaces of the positive meniscus lens L9, and both surfaces of the negative meniscus lens L10.

Next, an optical system according to an example 85 will be described below. FIG. 92A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 85. Moreover, FIG. 92B, FIG. 92C, FIG. 92D, and FIG. 92E are aberration diagrams of the optical system according to the example 85.

The optical system according to the example 85, as shown in FIG. 92A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconcave negative lens L9, a biconvex positive lens L10,

and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave 5 negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, 10 both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 86 will be described below. FIG. 93A is a cross-sectional view along an 15 optical axis showing an optical arrangement of the optical system according to the example 86. Moreover, FIG. 93B, FIG. 93C, FIG. 93D, and FIG. 93E are aberration diagrams of the optical system according to the example 86.

The optical system according to the example 86, as shown 20 in FIG. 93A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a 25 biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconcave negative lens L9, a biconvex positive lens L10, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both 40 surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the biconcave negative lens L9, both surfaces of the biconvex positive lens L10, and both surfaces of the 45 negative meniscus lens L11.

Next, an optical system according to an example 87 will be described below. FIG. **94**A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 87. Moreover, FIG. **94**B, 50 FIG. **94**C, FIG. **94**D, and FIG. **94**E are aberration diagrams of the optical system according to the example 87.

The optical system according to the example 87, as shown in FIG. 94A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, 55 and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed 60 toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, 65 a negative meniscus lens L9 having a convex surface directed toward the image side, a positive meniscus lens L10 having a

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convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 88 will be described below. FIG. 95A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 88. Moreover, FIG. 95B, FIG. 95C, FIG. 95D, and FIG. 95E are aberration diagrams of the optical system according to the example 88.

The optical system according to the example 88, as shown in FIG. 95A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a negative meniscus lens L6 having a convex surface directed toward the object side, a biconvex positive lens L7, a biconvex positive lens L8, a negative meniscus lens L9 having a convex surface directed toward the image side, a positive meniscus lens L10 having a convex surface directed toward the image side, and a negative meniscus lens L11 having a convex surface directed toward the object side. The negative meniscus lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11.

The aperture stop S is disposed between the biconcave negative lens L5 and the negative meniscus lens L6. More elaborately, the aperture stop is disposed between a vertex of an object-side surface of the biconcave negative lens L5 and a vertex of an image-side surface of the biconcave negative lens L5.

An aspheric surface is provided to 14 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, both surfaces of the positive meniscus lens L10, and both surfaces of the negative meniscus lens L11.

Next, an optical system according to an example 89 will be described below. FIG. **96A** is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 89. Moreover, FIG. **96B**, FIG. **96C**, FIG. **96D**, and FIG. **96E** are aberration diagrams of the optical system according to the example 89.

The optical system according to the example 89, as shown in FIG. 96A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a biconvex positive lens L3, a

positive meniscus lens L4 having a convex surface directed toward the image side, and a biconcave negative lens L5. The positive meniscus lens L4 and the biconcave lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens 5 L6, a biconvex positive lens L7, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the image side, a positive meniscus lens L11 having a convex surface directed toward the image side, and a negative meniscus lens L12 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave 15 negative lens L5 and the biconcave negative lens L6.

An aspheric surface is provided to 16 surfaces namely, both surfaces of the negative meniscus lens L1, both surfaces of the biconvex positive lens L2, both surfaces of the biconvex positive lens L3, both surfaces of the biconvex positive lens L8, 20 both surfaces of the biconvex positive lens L9, both surfaces of the negative meniscus lens L10, both surfaces of the positive meniscus lens L11, and both surfaces of the negative meniscus lens L12.

Next, an optical system according to an example 90 will be 25 described below. FIG. 97A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 90. Moreover, FIG. 97B, FIG. 97C, FIG. 97D, and FIG. 97E are aberration diagrams of the optical system according to the example 90.

The optical system according to the example 90, as shown in FIG. 97A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens 35 L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The biconcave negative lens L1 and the biconvex positive lens L2 are cemented. Moreover, 40 the biconvex positive lens L4, the positive meniscus lens L5, and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a 45 biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the 50 negative lens L6 and the negative meniscus lens L7. biconcave negative lens L12 and the positive meniscus lens

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

No aspheric surface is used.

Next, an optical system according to an example 91 will be described below. FIG. 98A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 91. Moreover, FIG. 98B, FIG. 98C, FIG. 98D, and FIG. 98E are aberration diagrams of 60 the optical system according to the example 91.

The optical system according to the example 91, as shown in FIG. 98A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 65

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3,

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a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The biconcave negative lens L1 and the biconvex positive lens L2 are cemented. Moreover, the biconvex positive lens L4, the positive meniscus lens L5, and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the biconcave negative lens L12 and the positive meniscus lens L13.

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

No aspheric surface is used.

Next, an optical system according to an example 92 will be described below. FIG. 99A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 92. Moreover, FIG. 99B, FIG. 99C, FIG. 99D, and FIG. 99E are aberration diagrams of the optical system according to the example 92.

The optical system according to the example 92, as shown in FIG. 99A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a negative meniscus lens L1 having a convex surface directed toward an image side, a positive meniscus lens L2 having a convex surface directed toward the image side, a biconvex positive lens L3, a positive meniscus lens L4 having a convex surface directed toward the object side, a biconvex positive lens L5, and a biconcave negative lens L6. The negative meniscus lens L1 and the positive meniscus lens L2 are cemented. Moreover, the biconvex positive lens L5 and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward the object side, a biconvex positive lens L11, and a negative meniscus lens L12 having a convex surface directed toward the object side. The negative meniscus lens $\ensuremath{\mathrm{L}} 7$ and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the negative meniscus lens L12.

The aperture stop S is disposed between the biconcave

No aspheric surface is used.

Next, an optical system according to an example 93 will be described below. FIG. 100A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 93. Moreover, FIG. 100B, FIG. 100C, FIG. 100D, and FIG. 100E are aberration diagrams of the optical system according to the example 93.

The optical system according to the example 93, as shown in FIG. 100A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a biconcave negative lens L1, a biconvex positive lens L2, a biconvex positive lens L3, a biconvex positive lens L4, a positive meniscus lens L5 having a convex surface directed toward an image side, and a biconcave negative lens L6. The biconcave negative lens L1 and the biconvex positive lens L2 are cemented. Moreover,

the biconvex positive lens L4, the positive meniscus lens L5, and the biconcave negative lens L6 are cemented.

The second lens unit G2 includes a negative meniscus lens L7 having a convex surface directed toward the object side, a biconvex positive lens L8, a biconvex positive lens L9, a 5 biconcave negative lens L10, a biconvex positive lens L11, a biconcave negative lens L12, and a positive meniscus lens L13 having a convex surface directed toward the object side. The negative meniscus lens L7 and the biconvex positive lens L8 are cemented. A predetermined lens unit includes the 10 biconcave negative lens L12 and the positive meniscus lens

The aperture stop S is disposed between the biconcave negative lens L6 and the negative meniscus lens L7.

No aspheric surface is used.

Next, an optical system according to an example 94 will be described below. FIG. 101A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 94. Moreover, FIG. 101B, grams of the optical system according to the example 94.

The optical system according to the example 94, as shown in FIG. 101A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power. 25

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a positive meniscus lens L2 having a convex surface directed toward the image side, a positive meniscus lens L3 having a convex surface directed toward the object side, a biconvex 30 positive lens L4, and a biconcave negative lens L5. The biconvex positive lens L4 and the biconcave negative lens L5 are cemented.

The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, 35 a biconcave negative lens L9, a biconvex positive lens L10, and a negative meniscus lens L11 having a convex surface directed toward the object side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the negative meniscus lens L11, 40

The aperture stop S is disposed between the biconcave negative lens L5 and the biconcave negative lens L6.

No aspheric surface is used.

Next, an optical system according to an example 95 will be described below. FIG. 102A is a cross-sectional view along 45 an optical axis showing an optical arrangement of the optical system according to the example 95. Moreover, FIG. 102B, FIG. 102C, FIG. 102D, and FIG. 102E are aberration diagrams of the optical system according to the example 95.

The optical system according to the example 95, as shown 50 in FIG. 102A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a 55 biconvex positive lens L2, a diffractive optical element DL, a biconvex positive lens L3, and a negative meniscus lens L4 having a convex surface directed toward the image side. The biconvex positive lens L3 and the negative meniscus lens L4 are cemented.

The second lens unit G2 includes a biconcave negative lens L5, a biconvex positive lens L6, a biconvex positive lens L7, a negative meniscus lens L8 having a convex surface directed toward the object side, a biconvex positive lens L9, a negative meniscus lens L10 having a convex surface directed toward 65 the object side, and a biconcave negative lens L11. The biconcave negative lens L5 and the biconvex positive lens L6 are

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cemented. A predetermined lens unit includes the negative meniscus lens L10 and the biconcave negative lens L11.

The diffractive optical element DL has a negative refractive power as a whole. The diffractive optical element DL includes a negative meniscus lens having a convex surface directed toward the image side and a biconcave negative lens. A relief pattern is formed at an interface of the negative meniscus lens and the biconcave negative lens, and the interface is let to be a diffractive surface.

The aperture stop S is disposed between the negative meniscus lens L4 and the biconcave negative lens L5.

An aspheric surface is provided to eight surfaces namely, an image-side surface of the positive meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L7, both surfaces of the negative meniscus lens L8, an object-side surface of the biconvex positive lens L9, and an image-side surface of the biconcave negative lens L11.

Next, an optical system according to an example 96 will be FIG. 101C, FIG. 101D, and FIG. 101E are aberration dia- 20 described below. FIG. 103A is a cross-sectional view along an optical axis showing an optical arrangement of the optical system according to the example 96. Moreover, FIG. 103B, FIG. 103C, FIG. 103D, and FIG. 103E are aberration diagrams of the optical system according to the example 96.

> The optical system according to the example 96, as shown in FIG. 103A, includes in order from an object side, a first lens unit G1 having a positive refractive power, an aperture stop S, and a second lens unit G2 having a positive refractive power.

> The first lens unit G1 includes a positive meniscus lens L1 having a convex surface directed toward an image side, a biconvex positive lens L2, a positive meniscus lens L3 having a convex surface directed toward the image side, a diffractive optical element DL, a biconvex positive lens L4, and a negative meniscus lens L5 having a convex surface directed toward the image side. The biconvex positive lens L4 and the negative meniscus lens L5 are cemented.

> The second lens unit G2 includes a biconcave negative lens L6, a biconvex positive lens L7, a biconvex positive lens L8, a negative meniscus lens L9 having a convex surface directed toward the object side, a biconvex positive lens L10, a biconcave negative lens L11, and a negative meniscus lens L12 having a convex surface directed toward the image side. The biconcave negative lens L6 and the biconvex positive lens L7 are cemented. A predetermined lens unit includes the biconcave negative lens L11 and the negative meniscus lens L12.

> The diffractive optical element DL has a negative refractive power as a whole. The diffractive optical element DL includes a negative meniscus lens having a convex surface directed toward the image side and a biconcave negative lens. A relief pattern is formed at an interface of the negative meniscus lens and the biconcave negative lens, and the interface is let to be a diffractive surface.

> The aperture stop S is disposed between the negative meniscus lens L5 and the biconcave negative lens L6.

> An aspheric surface is provided to eight surfaces namely, an image-side surface of the positive meniscus lens L1, an object-side surface of the biconvex positive lens L2, both surfaces of the biconvex positive lens L8, both surfaces of the negative meniscus lens L9, an object-side surface of the biconvex positive lens L10, and an image-side surface of the negative meniscus lens L12.

> Next, numerical data of optical components comprising the image pickup optical system of each above example are shown. In numerical data of each example, r1, r2, ... denotes a curvature radius of each lens surface, d1, d2, . . . denotes a thickness of each lens or an air distance between adjacent lens surfaces, nd1, nd2, ... denotes a refractive index of each lens

-continued

for d-line, v1, vd2, . . . denotes an Abbe number of each lens, * denotes an aspheric surface, focal length denotes a focal length of an overall optical system, fb denotes a back focus, NA denotes a numerical aperture on the object side, NA' denotes a numerical aperture on an image side. The lens total length is the distance from the frontmost lens surface to the rearmost lens surface plus back focus. Further, back focus is a unit which is expressed upon air conversion of a distance from the lens backmost surface to a paraxial image surface.

A shape of an aspheric surface is defined by the following expression where the direction of the optical axis is represented by z, the direction orthogonal to the optical axis is represented by y, a conical coefficient is represented by K, aspheric surface coefficients are represented by A4, A6, A8, A10, A12, A14,

$$Z = (y^2/r) / \left[1 + \left\{ 1 - (1+k)(y/r)^2 \right\}^{1/2} \right] + \\ A4y^4 + A6y^6 + A8y^8 + A10y^{10} + A12y^{12} + A14y^{14} \quad ^{20}$$

Further, E or e stands for exponent of ten. These symbols are commonly used in the following numerical data for each example.

Example 1

Surface data							
Surface no.	r	d	nd	νd			
Object plane	8	10.00					
1*	56.907	2.99	1.53368	55.90			
2*	-4.184	0.89					
3*	5.571	2.08	1.63490	23.88			
4*	2.582	1.78					
5*	-12.567	1.55	1.53368	55.90			
6*	-9.471	0.16					
7*	-81.714	1.53	1.61417	25.64			
8*	16.993	1.27					
9*	10.146	0.89	1.53368	55.90			
10*	2551.254	0.05					
11(Stop)	œ	0.05					
12*	-2551.254	0.89	1.53368	55.90			
13*	-10.146	1.27					
14*	-16.993	1.53	1.61417	25.64			
15*	81.714	0.16					
16*	9.471	1.55	1.53368	55.90			
17*	12.567	1.78					
18*	-2.582	2.08	1.63490	23.88			
19*	-5.571	0.89					
20*	4.184	2.99	1.53368	55.90			
21*	-56.907	10.00					

21*	-56.907	10.00
Image plane	∞	
	Aspherical s	surface data
1st surface		
k = _071 414		
k = -971.414 A4 = 5.02632E-0	04. A6 = -1.899	089E-005, A8 = 7.41491E-008
	04, A6 = -1.899	989E-005, A8 = 7.41491E-008
A4 = 5.02632E-0 2nd surface	04, A6 = -1.899	089E-005, A8 = 7.41491E-008
A4 = 5.02632E - 0 2nd surface $k = -3.546$,
A4 = 5.02632E - 0 2nd surface $k = -3.546$		089E-005, A8 = 7.41491E-008 0925E-006, A8 = -7.12080E-008

A4 = -3.68418E - 004, A6 = 1.23021E - 006, A8 = -1.91476E - 007

	Unit mm
4th s	nurface
A4 =	-2.549 = -5.11751E-005, A6 = 2.59016E-005, A8 = -4.23106E-006 surface
A4 =	-41.834 = 1.16926E-003, A6 = 4.04202E-005, A8 = 5.90751E-007 surface
A4 =	-10.826 - $1.20017E-003$, $A6 = -1.67324E-004$, $A8 = 1.00681E-005$ surface
A4 =	-323.372 = -1.33721E-003, A6 = -7.57104E-005 nurface
A4 =	-56.057 -5.62466E-004, A6 = 2.31800E-005 purface
A4 =	-8.574 = -4.31572E-004, A6 = 7.85879E-006 surface
A4 =	-3367.122 -1.08162E-003 surface
A4 =	-3367.122 = 1.08162E-003 surface
A4 =	-8.574 4.31572E-004, A6 = -7.85879E-006 surface
A4 =	-56.057 -5.62466E-004, A6 = -2.31800E-005 surface
A4 =	-323.372 = 1.33721E-003, A6 = 7.57104E-005 surface
A4 =	-10.826 = -1.20017E-003, A6 = 1.67324E-004, A8 = -1.00681E-005 surface
A4 =	-41.834 = -1.16926E-003, A6 = -4.04202E-005, A8 = -5.90751E-007 surface
A4 =	-2.549 = 5.11751E-005, A6 = -2.59016E-005, A8 = 4.23106E-006 surface
A4 =	-0.820 = 3.68418E-004, A6 = -1.23021E-006, A8 = 1.91476E-007 surface
A4 =	-3.546 -1.17216E-004, A6 = 3.40925E-006, A8 = 7.12080E-008 surface

Various data				
Focal length	103.95			
Image height	3.00			
Object height	3.00			
fb (in air)	10.00			

k = -971.414

60

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-continued							-Co	ontinued		
Unit mm							1	Unit mm		
				- 5	9th surface					
Lens total length (in air) 36.40 NA 0.25 NA' 0.25			3	k = -8.574 A4 = -4.315721 10th surface	E-004, A 6 = 7	.85879E-00	6			
	F	1.2			10	k = -3367.122 A4 = -1.081621 12th surface	E-003			
	Exam	ipie 2				k = -1.000 A4 = 1.01390E- 13th surface	-003			
	Unit	mm			— 15	k = -34.706 A4 = 1.53163E-	-004. A6 = -3	.32586E-00	5	
	Surfac	e data			_	14th surface				
Surface no.	r	d	nd	νd	_	k = -115.470 A4 = -3.35747I	F_004 A 6 = _	.6 40043F_0	05 48 = _2 43	136E_0
Object plane 1* 2*	∞ 56.907 -4.184	10.00 2.99 0.89	1.53368	55.90	20	$\frac{15\text{th surface}}{15\text{th surface}}$			03, A6 = -2.43	1301-00
3* 4*	5.571 2.582	2.08 1.78	1.63490	23.88		A4 = 3.76944E- 16th surface	-004, A6 = 7.2	29277E-005	A8 = -4.82792	2E-007
5*	-12.567	1.55	1.53368	55.90	25					
6* 7*	-9.471 -81.714	0.16 1.53	1.61417	25.64	23	k = -8.155 A4 = -1.453901	E-003, A6 = 1	.19689E-00	4, A8 = -4.239	58E-006
8* 9*	16.993	1.27 0.89	1 52260	55.00		17th surface				
10*	10.146 2551.254	0.89	1.53368	55.90		k = -54.092				
11(Stop)	∞	0.05				A4 = -1.438171	E-003, A6 = -	4.56510E-0	05, A8 = -9.34	587E-00
12*	-2755.354	0.88	1.53368	55.90	30	18th surface				
13* 14*	-10.197 -17.162	1.27 1.52	1.61417	25.64		k = -2.544				
15*	80.905	0.16	1.01-117	23.04		A4 = -2.217381	E-004, A6 = -	1.23369E-0	05. A8 = 1.788	75E-00
16*	9.945	1.51	1.53368	55.90		19th surface	,		,	
17*	13.196	1.78	1 (2400	22.00						
18* 19*	-2.579 -5.515	2.10 0.89	1.63490	23.88	35	k = -0.962 A4 = 5.90516E	_004 460	40003F_00	7 48 - 2 83619	0F_007
20*	4.205	3.01	1.53368	55.90		20th surface	001,710 = 3	.1009512 00	7,110 - 2.0501.)L 00,
21*	-52.429	9.95								
Image plane	∞				_	k = -3.386 A4 = -5.94157I	E-004, A6 = -	2.05054E-0	05, A8 = -1.51	161E-00
	Aspherical s	surface da	ta		4 0	21th surface				
1st surface					_	k = -997.069 A4 = -1.39558I	E-003, A6 = 3	.03292E-00	8, A8 = -2.097	82E-007
k = –971.414 A4 = 5.02632E– 2nd surface	004, A6 = -1.899	989E-005	, A8 = 7.4149	1E-008	_		Va	irious data		
					- ₄₅ -	Focal	length		117.5	4
k = -3.546	004 AC 2 46	nasti ee	C A O 712	000E 000		Image	height		3.0	
A4 = -1.1 /216E 3rd surface	−004, A6 = −3.40	i9∠3E−UU	o, Ao = -/.12	800-1008		Objec fb (in	t height air)		3.0- 9.9	
						,	an) total length (in	ı air)	36.3	
k = -0.820	004 46 1 222	01E 005	40 1011	7CE 007	50	NA	- `		0.2	
A4 = -3.68418E 4th surface	-004, A6 = 1.230	/Z1E-006	, Ao = -1.914	/OE-UU/	50 _	NA'			0.2)
l. 2.540										
k = -2.549 A4 = -5.11751E 5th surface	-005, A6 = 2.590)16E-005	, A8 = -4.231	06E-006	_		Ex	cample 3		
k = -41.834					55					
	003, A6 = 4.0420	02E-005, .	A8 = 5.90751	E-007	_		τ	Unit mm		
6th surface					_		Su	ırface data		
					_					
k = -10.826 A4 = 1.20017E-	003, A6 = -1.673	324E-004	, A8 = 1.0068	1E-005	60	Surface no.	r	d	nd	νd
k = -10.826 A4 = 1.20017E-17th surface k = -323.372 A4 = -1.33721E	003, A6 = -1.673 -003, A6 = -7.57			1E-005	60	Object plane	∞ 24.287	10.00 3.82	nd 1.53368	
$\frac{7\text{th surface}}{k = -323.372}$				1E-005	⁶⁰ _	Object plane	o	10.00		55.90 55.90
k = -10.826 A4 = 1.20017E-17th surface k = -323.372 A4 = -1.33721E 8th surface k = -56.057		7104E-00		1E-005		Object plane 1* 2*	∞ 24.287 −8.002	10.00 3.82 0.24	1.53368	55.90

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-continued		

	-cc	ontinued					-con	linued		
	Ţ	Jnit mm					Uni	t mm		
6*	2.521	2.46				15th surface				
7*	-5.494	1.55	1.53368	55.90	5					
8*	-8.447	0.84				k = -11.820				
9*	-19.714	1.55	1.61417	25.64		A4 = 1.83703E - 0	003, A6 = -5.10	296E-005		
10*	62.109	0.30				16th surface				
11*	8.611	1.45	1.53368	55.90		<u>, </u>				
12*	83.241	0.10				k = -112.335				
13(Stop)	00	0.10			10	A4 = 4.38857E - 0	004, A6 = -7.19	917E-005		
14*	-83.241	1.45	1.53368	55.90		17th surface				
15*	-8.611	0.30								
16*	-62.109	1.55	1.61417	25.64		k = -144.855				
17*	19.714	0.84	1 522 60	55.00		A4 = 1.30120E-0	003, A6 = 1.924	46E-004		
18* 19*	8.447	1.55	1.53368	55.90		18th surface				
20*	5.494 -2.521	2.46 1.71	1.63490	23.88	15	k = -29.993				
21*	-5.062	0.10	1.03490	23.00		A4 = -23.31315E	-003 46 = 267	174E_004	A8 = _8 203	78E_006
22*	5.934	1.65	1.53368	55.90		A4 = -2.3131315 19th surface	-003, A0 = 2.07	1746-004	$A_0 = -6.203$	78E-000
23*	41.811	0.24	1.55500	33.20		17th surface				
24*	8.002	3.82	1.53368	55.90		k = -13.090				
25*	-24.287	10.00	1.55500	55.50	• •	A4 = -2.91976E	-003. $A6 = 9.94$	891E-005	A8 = -3.387	74E-006
Image plane	∞	20.00			20	20th surface	,		,110 01007	
					_					
	Aspheric	cal surface d	ata			k = -2.293				
	•				_	A4 = 1.77915E - 0	003			
1st surface						21th surface				
					25					
k = -38.162					25	k = -2.669				
	E-004, A6 = -1.	95771E-00:	5			A4 = 6.29227E - 0	004			
2nd surface						22th surface				
k = 0.297	T. 004					k = -8.215	004.46.4.:=	0.4375 00 -		
A4 = 1.77235	E-004				20	A4 = -3.34614E-	-004, A6 = 1.45	043E-005		
3rd surface					30	23th surface				
lr = 51 606						lr = 51 606				
k = 51.696 A4 = -7.9666	57E_005					k = 51.696 A4 = 7.96667E-0	005			
A4 = - /.9666 4th surface	2/12-003					A4 = 7.9666/E-0 24th surface	0.03			
-m surrace						2-m surface				
k = -8.215					35	k = 0.297				
	1E-004, $A6 = -1$.	45043E-00	5		33	A4 = -1.77235E	-004			
5th surface	,		-			25th surface				
k = -2.669						k = -38.162				
A4 = -6.2922	27E-004					A4 = -2.16640E	-004, A6 = 1.95	771E-005		
6th surface					40 -					
							Vario	us data		
k = -2.293					_		-1			2
A4 = -1.7791	15E-003					Focal le			-66.5	
7th surface						Image l			3.0	
					_	Object I			3.0	
k = -13.090					45	fb (in ai		-A	10.0	
	5E-003, $A6 = -9$.	94891E-00	5, A8 = 3.3877	4E-006		3.7.4	tal length (in air	IJ	41.5	
8th surface						NA NA'			0.2 0.2	
						INA			0.2	-
k = -29.993										
	5E-003, $A6 = -2$.	67174E-00	4, A8 = 8.2037	8E-006						
9th surface					50		Exan	aple 4		
				_			LAdii	-г		
k = -144.855										
A4 = -1.3012	20E-003, $A6 = -3$	1.92446E-0	04							
					_		Unit	t mm		
10th surface					55			a a d-4-		
10th surface k = -112.335		19917E-00:	5		_		Surfa	ce data		
10th surface k = -112.335 A4 = -4.3885	57E-004, A6 = 7.					Surface no.	r	d	nd	vd
10th surface k = -112.335 A4 = -4.3885					_	Burrace IIO.	1	u	IId	vu
10th surface k = -112.335 A4 = -4.3885 11th surface						Object plane	∞	10.00		
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820	57E-004, A6 = 7.		_					10.00		
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.8370		10296E-00:	5			1*	118 590	3 22	1.53368	55.90
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.8370	57E-004, A6 = 7.	10 29 6E-00:	5		60	1* 2*	118.590 -4.253	3.22 1.22	1.53368	55.90
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.8370 12th surface	57E-004, A6 = 7. 03E-003, A6 = 5.	10296E-00:	5		60		-4.253	1.22		
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.8370 12th surface	57E-004, A6 = 7. 03E-003, A6 = 5.	10 2 96E-00:	5		60	2*	-4.253 5.650	1.22 2.03	1.53368 1.63490	55.90 23.88
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.837(12th surface k = -992.499	57E-004, A6 = 7.	10296E-00:	5		60	2* 3*	-4.253	1.22		23.88
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.837(12th surface k = -992.499 A4 = -2.2693	57E-004, A6 = 7.	10296E-00:	5		60	2* 3* 4*	-4.253 5.650 2.592	1.22 2.03 2.12	1.63490	
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820 A4 = -1.837(12th surface k = -992.499 A4 = -2.2693	57E-004, A6 = 7.	10296E-00.	5		_	2* 3* 4* 5*	-4.253 5.650 2.592 -12.289	1.22 2.03 2.12 1.26	1.63490	23.88
10th surface k = -112.335 A4 = -4.3885 11th surface k = -11.820	57E-004, A6 = 7. 03E-003, A6 = 5. 37E-003	10296E-00:	5			2* 3* 4* 5* 6*	-4.253 5.650 2.592 -12.289 -10.692	1.22 2.03 2.12 1.26 0.42	1.63490 1.53368	23.88 55.90

14/	120
-continued	-continued

	Unit	mm			_		Unit	mm		
10*	-1637.972	0.05				16th surface				
11(Stop) 12*	∞ 1637.972	0.05 1.21	1.53368	55.90	5	k = -10.478				
13* 14*	-9.307 -18.173	0.91 0.75	1.61417	25.64		A4 = -1.17511E - 17th surface	-003, A6 = 2.785	573E-004	, A8 = -1.449	45E-005
15* 16* 17*	-2017.727 10.692 12.289	0.42 1.26 2.12	1.53368	55.90	10	k = -40.369 A4 = -1.42420E-	004 46 - 3 866	1005 005	A9 - 7112	30E 006
18* 19*	-2.552 -4.995	1.28 0.20	1.63490	23.88	10	18th surface	-004, A0 = 3.80-	108E-003	, A6 = -7.112	3912-000
20* 21* 22*	-8.574 -10.336 4.253	1.73 0.27 3.22	1.61417 1.53368	25.64 55.90		k = -2.482 A4 = 8.47704E-0 19th surface	004, A6 = -1.736	583E-005		
23* Image plane	-118.590 ∞	10.00	1.55506	33.90	15	k = -1.007				
	Aspherical s	surface da	ta		_	A4 = 1.61790E-0 20th surface	003, A6 = -3.906	552E-005		
1st surface					- 	k = -5.877 A4 = 7.79125E-0	004. A6 = -1.325	507E-005		
k = -8136.470						21th surface				
2nd surface	-004, A6 = -2.006	14E-005			_	k = -1.068 A4 = 5.79930E-0 22th surface	004, A6 = 8.8642	27E-007		
k = -3.272 A4 = 9.59493E- 3rd surface	-005, A6 = -1.268	26E-005			25 —	k = -3.272 $A4 = -9.59493E$	-005, A6 = 1.268	326E-005		
k = -1.068 A4 = -5.23801E 4th surface	∃–004					23th surface k = -8136.470 A4 = -5.71134E-	-004, A6 = 2.006	514E-005		
k = -2.482					— 30 –		Variou	ıs data		
A4 = -8.74470E 5th surface	E-004					Focal le Image l	neight		60.48	
k = -40.369 A4 = 1.42420E- 6th surface	-004, A6 = -3.864	08E-005,	, A8 = 7.1123	9E-006	35	Object: fb (in a	ir)	`	3.00 10.00 36.64)
					_	NA	tal length (in air	,	0.25	;
A4 = 1.17511E-	-003, A6 = -2.785	73E-004,	, A8 = 1.4494				tai rengui (ili air			;
A4 = 1.17511E- 7th surface k = -29.482 A4 = -1.47024E	-003, A6 = -2.785 ∃-003, A6 = -9.25			5E-005	40	NA	Exam		0.25	;
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068	∃-003, A6 = -9.25	880E-00.			40 40 45	NA		aple 5	0.25	;
A4 = 1.17511E- 7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-		880E-00.				NA NA'	Exam	mm	0.25	
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721	3-003, A6 = -9.25 -004, A6 = 2.1233	2E-005				NA NA'	Exam Unit Surfac r	mm e data	0.25	;
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E	∃-003, A6 = -9.25	2E-005				NA NA' Surface no. Object plane 1*	Exam Unit Surfac r	mm e data d 10.00 2.97	0.25 0.25	
7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E- 9th surface k = -8.721	∃-003, A6 = -9.25 -004, A6 = 2.1233 ∃-004, A6 = 1.030	2E-005			- 45 <u>-</u> -	Surface no. Object plane 1* 2* 3* 4*	Exam Unit Surfac r	mm e data d	0.25 0.25	vd
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E 10th surface k = -9998.897 A4 = -9.87805E 12th surface	∃-003, A6 = -9.25 -004, A6 = 2.1233 ∃-004, A6 = 1.030	2E-005			45	Surface no. Object plane 1* 2* 3* 4* 5* 6*	Unit Surfac r 6 156.483 -4.185 5.631 2.482 -12.289 -10.692	mm e data 10.00 2.97 0.64 2.24 2.06 1.26 0.30	nd 1.53368 1.63490 1.53368	vd 55.90 22.53 55.90
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E 10th surface k = -9998.897 A4 = -9.87805E 12th surface k = -9998.897 A4 = 9.87805E-	\exists -003, A6 = -9.25 -004, A6 = 2.1233 \exists -004, A6 = 1.030	2E-005			- 45 <u>-</u> -	Surface no. Object plane 1* 2* 3* 4* 5*	Unit Surfac r	mm e data d 10.00 2.97 0.64 2.24 2.06 1.26	nd 1.53368 1.63490	vd 55.90 22.53
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E10th surface k = -9998.897 A4 = -9.87805E12th surface k = -9998.897 A4 = 9.87805E13th surface k = -8.721	∃-003, A6 = -9.25 -004, A6 = 2.1233 ∃-004, A6 = 1.030 ∃-004	2E-005 02E-005			45	NA NA' Surface no. Object plane 1* 2* 3* 4* 5* 6* 7* 8* 9* 10* 11(Stop)	Exam Unit Surface r 6 156.483 -4.185 5.631 2.482 -12.289 -10.692 749.711 20.875 9.307 -1637,972 6	mm e data d 10.00 2.97 0.64 2.24 2.06 1.26 0.30 0.75 0.91 1.21 0.05 0.05	nd 1.53368 1.63490 1.53368 1.61417 1.53368	vd 55.90 22.53 55.90 26.36 55.90
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E-12th surface k = -9998.897 A4 = -9.87805E-12th surface k = -9998.897 A4 = 9.87805E-13th surface k = -8.721 A4 = 3.04856E-13th surface	\exists -003, A6 = -9.25 -004, A6 = 2.1233 \exists -004, A6 = 1.030	2E-005 02E-005			45	Surface no. Object plane 1* 2* 3* 4* 5* 6* 7* 8* 9* 10*	Exam Unit Surfac r	mm e data 10.00 2.97 0.64 2.24 2.06 1.26 0.30 0.75 0.91 1.21 0.05	nd 1.53368 1.63490 1.53368 1.61417	vd 55.90 22.53 55.90 26.36
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E 10th surface k = -9998.897 A4 = -9.87805E-12th surface k = -9998.897 A4 = 3.04856E-14th surface k = -8.721 A4 = 3.04856E-14th surface k = -8.721 A4 = 3.04856E-14th surface	∃-003, A6 = -9.25 -004, A6 = 2.1233 ∃-004, A6 = 1.030 ∃-004 -004	2E-005 02E-005	5		45 50	NA NA' Surface no. Object plane 1* 2* 3* 4* 5* 6* 7* 8* 9* 10* 11(Stop) 12* 13* 14* 15* 16*	Exam Unit Surface r \$\infty\$ 156.483 -4.185 5.631 2.482 -12.289 -10.692 749.711 20.875 9.307 -1637.972 \$\infty\$ 1637.972 -9.307 -16.779 -107.079 10.692	nple 5 mm e data 10.00 2.97 0.64 2.24 2.06 1.26 0.30 0.75 0.91 1.21 0.05 1.21 0.36 1.62 0.10 1.26	nd 1.53368 1.63490 1.53368 1.61417 1.53368 1.53368	vd 55.90 22.53 55.90 55.90
A4 = 1.17511E-7th surface k = -29.482 A4 = -1.47024E 8th surface k = -73.068 A4 = 2.28159E-9th surface k = -8.721 A4 = -3.04856E 10th surface k = -9998.897 A4 = -9.87805E-12th surface k = -9998.897 A4 = 3.04856E-14th surface k = -8.721 A4 = 3.04856E-14th surface k = -8.721 A4 = 3.04856E-14th surface	∃-003, A6 = -9.25 -004, A6 = 2.1233 ∃-004, A6 = 1.030 ∃-004	2E-005 02E-005	5		45 50	NA NA' Surface no. Object plane 1* 2* 3* 4* 5* 6* 7* 8* 9* 10* 11(Stop) 12* 13* 14* 15*	Exam Unit Surfac r 6 156.483 -4.185 5.631 2.482 -12.289 -10.692 749.711 20.875 9.307 -1637.972 6 1637.972 -9.307 -16.779 -107.079	mm e data 10.00 2.97 0.64 2.24 2.06 0.30 0.75 0.91 1.21 0.05 0.05 1.21 0.36 1.62 0.10	nd 1.53368 1.63490 1.53368 1.61417 1.53368 1.61417	vd 55.90 22.53 55.90 26.36 55.90 29.34

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129	150						
-continued			-contin	nued			
Unit mm	_	Unit mm					
22* 4.898 4.02 1.53368 55.90		19th surface					
23* -20.043 18.15 Image plane ∞	5 –		003, A6 = -1.2432	24E-004			
Aspherical surface data	_	20th surface					
1st surface k = -9921.522	— 10	k = -2.596 A4 = 3.85952E - 6 21th surface	003, A6 = -1.2339	99E-004			
A4 = 5.99647E-004, A6 = -2.35081E-005, A8 = -3.20796E-007 2nd surface k = -3.735	_	k = -50.829 A4 = 9.71515E-0 22th surface	004, A6 = -1.0338	34E-005			
A4 = -2.94840E-005, A6 = -9.87589E-006, A8 = -3.04656E-007 3rd surface	15	k = -5.617	-005, A6 = -1.518	331E-005, A	.8 = 2.25669E	E-007	
k = -1.357 A4 = -7.07427E-004, A6 = 1.47946E-006, A8 = 1.15313E-007		23th surface					
4th surface	– ₂₀	k = -1.000 A4 = -4.00926E	-004, A6 = -3.906	504E-006, A	.8 = -5.44114	E-008	
k = -2.659 A4 = -7.98462E-004, A6 = -2.43747E-005, A8 = 5.79988E-007			Various	data			
5th surface	_	Focal le			26.53		
k = -40.369 A4 = 1.42420E-004, A6 = -3.86408E-005, A8 = 7.11239E-006 6th surface	25	Image Object fb (in a	height		5.00 2.99 18.15		
	_	Lens to	tal length (in air)		46.84		
k = -10.478 A4 = 1.17511E-003, A6 = -2.78573E-004, A8 = 1.44945E-005 7th surface	— 30	NA NA'			0.25 0.15		
k = -2.268 A4 = -1.14080E-004, A6 = -1.24060E-004, A8 = -2.30974E-006 8th surface	_		Examp	ole 6			
k = -31.531 A4 = 4.20068E-004, A6 = 7.16535E-005, A8 = -5.41984E-006 9th surface	35		Unit r	nm			
k = -8.721		-	Surface				
A4 = -3.04856E-004, A6 = 1.03002E-005 10th surface	40	Surface no.	r	d	nd	νd	
k = -9998.897 A4 = -9.87805E-004		Object plane 1* 2*	∞ -0.784 -130.797	1.21 0.48 0.05	1.53071	55.78	
12th surface	_	3*	0.642	0.59	1.53071	55.78	
k = -9998.897	45	4* 5*	2.354 -2.684	0.49 0.29	1.63490	23.88	
A4 = 9.87805E-004 13th surface		6*	17.387	0.04			
15th burnec	_	7* 8*	2.980	0.70	1.53071	55.78	
k = -8.721		8** 9(Stop)	−1.789 ∞	-0.11 0.21			
A4 = 3.04856E-004, A6 = -1.03002E-005		10*	1.410	0.54	1.53463	56.22	
14th surface	50	11*	-25.302	0.05	1 62 105	22.00	
k = -70.427		12* 13*	-63.214 2.768	0.30 0.71	1.63490	23.88	
A4 = 1.69673E-004, A6 = -2.70114E-005, A8 = 1.08912E-007		14*	-2.355	0.71	1.53463	56.22	
15th surface		15*	-0.912	0.13			
	_	16*	-251.493	0.59	1.53463	56.22	
k = -9997.910 A4 = 1.71452E-003, A6 = 1.19083E-004, A8 = -3.69775E-006 16th surface	55	17* Image plane	1.312 ∞	1.46			
	_		Aspherical su	ırtace data			
k = -10.478 A4 = -1.17511E-003, A6 = 2.78573E-004, A8 = -1.44945E-005 17th surface	60	1st surface k = -7.734					
k = -40.369 A4 = -1.42420E-004, A6 = 3.86408E-005, A8 = -7.11239E-006 18th surface		A4 = 1.18541E-001, A10 = -7.67536E-00. 2nd surface				-005	
	_	k = 0.000					

A4 = 4.04572E-004, A6 = -8.29704E-005

k = -2.482

 $\begin{array}{c} k=0.000 \\ 65 \quad A4=8.48095E-002, A6=-1.72116E-002, A8=-1.25962E-002, \\ A10=6.37573E-003, A12=-8.49967E-004, A14=-3.53042E-006 \end{array}$

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Unit mm		Unit mm						
3rd surface k = -3.546 A4 = 2.70583E-001, A6 = -2.54490E-001, A8 = 1.89589E-001,	5	fb (in air) Lens tota NA) l length (in air)		1.46 7.16 0.22			
A10 = -1.87543E-001, A12 = 5.94237E-002 4th surface		NA'			0.17			
x = -1.947 A4 = 9.60228E-002, A6 = -2.78077E-002, A8 = -2.47936E-003, A10 = -5.89337E-002, A12 = 1.60644E-001 5th surface	10		Exam	ple 7				
x = -24.611 A4 = -1.29167E - 001, $A6 = 1.92617E - 001$, $A8 = -6.67246E - 002$, A10 = -9.41339E - 002, $A12 = -7.64900E - 0026th surface$	15		Unit ı					
000,00 = 2			Surface	data				
A4 = 7.10538E-002, A6 = 3.04047E-001, A8 = -7.45538E-001, A10 = -1.67999E-001, A12 = 5.47114E-001 7th surface	20	Surface no. Object plane	r	d 1.46	nd	vd		
		1*	-1.312	0.59	1.53463	56.22		
x = -4.762 A4 = 9.68323E - 002, $A6 = 3.65189E - 001$, $A8 = -8.02417E - 001$,		2* 3*	251.493 0.912	0.13 0.65	1.53463	56.22		
A10 = 7.47746E - 002, $A0 = 3.03189E - 001$, $A8 = -8.02417E - 001$, $A10 = 7.47746E - 002$, $A12 = 6.35189E - 001$		4*	2.355	0.71	1.55 105	55.22		
8th surface	2.5	5*	-2.768	0.30	1.63490	23.88		
	25	6 *	63.214	0.05	1 52462	56.00		
K = -0.571		7* 8*	25.302 -1.410	0.54 0.21	1.53463	56.22		
A4 = 4.95207E - 002, $A6 = -1.12153E - 001$, $A8 = 7.03902E - 001$, $A10 = -1.28927E + 000$, $A12 = 1.11371E + 000$		9(Stop)	-1.410 ∞	-0.11				
.0th surface		10*	1.789	0.70	1.53071	55.78		
		11*	-2.980	0.04				
= 0.062	30	12*	-17.387	0.29	1.63490	23.88		
A4 = 1.37414E - 002, $A6 = -5.71487E - 002$, $A8 = -3.66765E - 002$,		13*	2.684	0.49				
A10 = 4.18364E-001, A12 = -4.83502E-001		14*	-2.354	0.59	1.53071	55.78		
1th surface		15* 16*	-0.642 130.797	0.05 0.48	1.53071	55.78		
=0.000		17*	0.784	1.21	1.55071	33.76		
A4 = 1.42573E - 001, $A6 = -6.53135E - 001$, $A8 = 3.84898E - 001$,	35	Image plane	∞	1.21				
A10 = 2.63676E+000, $A12 = -3.61580E+000$, $A14 = 4.20017E-00A16 = 4.40252E-001$, i,		Aspherical s	urface data				
2th surface		1st surface						
x = -495.266 A4 = 1.85957E-001, A6 = -8.01875E-001, A8 = 7.78375E-001, A10 = 2.01491E+000, A12 = -2.75814E+000 13th surface	40	k = -9.247 A4 = 7.76409E-002, A10 = -1.79672E-00				-005		
k = -4.665 A4 = 1.82826E-001, A6 = -3.29495E-001, A8 = 5.73943E-001, A10 = -1.56281E-001, A12 = -1.45670E-001	45	2nd surface k = -420.200 A4 = 4.70698E-002,		,	,			
14th surface	45	A10 = 4.41443E-003 3rd surface	, A12 = -5.27904	E-004, A14 :	= 2.63829E-0			
k = -1.122 A4 = -5.90880E-002, A6 = 1.80998E-001, A8 = -4.20905E-001, A10 = 3.48644E-001, A12 = -1.35538E-001 15th surface	50	k = -4.154 A4 = 2.53695E-001, A10 = -1.58499E-00 4th surface			37286E-001,			
k = -4.154 A4 = -2.53695E-001, A6 = 3.45811E-001, A8 = -3.37286E-001, A10 = 1.58499E-001, A12 = -2.70778E-002 16th surface		k = -1.122 A4 = 5.90880E-002, A10 = -3.48644E-00 5th surface			20905E-001,			
k = -420.200 A4 = -4.70698E-002, A6 = -1.74511E-002, A8 = 1.68346E-002, A10 = -4.41443E-003, A12 = 5.27904E-004, A14 = -2.63829E-0 17th surface	55	k = -4.665 A4 = -1.82826E-001 A10 = 1.56281E-001 6th surface	,	,	5.73943E-001	.,		
x = -9.247 A4 = -7.76409E-002, A6 = 2.54240E-002, A8 = -8.61348E-003, A10 = 1.79672E-003, A12 = -2.29048E-004, A14 = 1.31057E-00		k = -495.266 A4 = -1.85957E-001 A10 = -2.01491E+00 7th surface	*	,	7.78375E-001	.,		
Various data		k = 0.000						
Focal length 1.52 Image height 2.85 Object height 2.24	65	R = 0.000 A4 = -1.42573E-001 A10 = -2.63676E+00 A16 = -4.40252E-00	0, A12 = 3.61580					

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Unit mm			Unit mm						
th surface			10	-552.475	1.65	1.61800	63.33	0.544	
= 0.062 A4 = -1.37414E-002, A6 = 5.71487E-002, A8 A10 = -4.18364E-001, A12 = 4.83502E-001 Oth surface	= 3.66765E-002,	5	11 12* 13* 14* 15*	-30.000 7.964 29.995 105.854 -9.793	0.10 2.99 1.94 2.67 5.72	1.49700 1.58364	81.61 30.30	0.538 0.599	
x = -0.571 A4 = -4.95207E-002, A6 = 1.12153E-001, A8 A10 = 1.28927E+000, A12 = -1.11371E+000 11th surface	= -7.03902E-001,	10	16* 17* 18 19 Image plane	-5.613 4970.723	0.70 3.70 0.30 0.31	1.53368 1.51640	55.90 65.06	0.563 0.535	
x = -4.762	9 9.02417E 001			ace data					
A4 = -9.68323E-002, A6 = -3.65189E-001, A A10 = -7.47746E-002, A12 = -6.35189E-001 12th surface	15		4th surface						
k = 0.000 A4 = -7.10538E-002, A6 = -3.04047E-001, A			k = 0.000 A4 = 7.06954e-0: 12th surface	5					
A10 = 1.67999E-001, A12 = -5.47114E-001 13th surface k = -24.611 A4 = 1.20167E-001, A6 = -1.92617E-001, A8			k = -0.579 A4 = 3.23636e-09 13th surface	8					
A4 = 1.29167E-001, A6 = -1.92617E-001, A8 = 6.67246E-002, A10 = 9.41339E-002, A12 = 7.64900E-002 4th surface				k = 0.000 A4 = 1.99801e-03 14th surface	5				
k = -1.947 A4 = -9.60228E-002, A6 = 2.78077E-002, A8 A10 = 5.89337E-002, A12 = -1.60644E-001 15th surface	= 2.47936E-003,			k = 0.000 A4 = -5.42705e-15th surface	04				
k = -3.546 A4 = -2.70583E-001, A6 = 2.54490E-001, A8 A10 = 1.87543E-001, A12 = -5.94237E-002 16th surface	= -1.89589E-001,	30		k = 0.000 A4 = -1.29917e-1 16th surface	05				
k = 0.000 A4 = -8.48095E-002, A6 = 1.72116E-002, A8 A10 = -6.37573E-003, A12 = 8.49967E-004, A		35	k = 0.000 A4 = 4.43608e-04 17th surface						
17th surface k = -7.734 A4 = -1.18541E-001, A6 = 5.85984E-002, A8				k = 0.000 $A4 = -7.74339e - 0.000$	04, A6 = - Various da		5		
A10 = 7.67536E-003, A12 = -1.18366E-003, A14 = 7.33016E-005		40		agnification			0.15 -1.04		
Various data		_		cal length age height (mm)			9.34 4.92		
Focal length Image height	1.52 2.24		fb	(mm) (in air) ns total length (mm)	(in air)		4.21 34.92		
Object height fb (in air) Lens total length (in air) NA NA'	2.85 1.21 6.91 0.17 0.22	45		E	Example	9			

Example 8

		Unit mm			
		Surface dat	ta		
Surface no.	r	d	nd	vd	$\theta g f$
1	20.000	3.16	1.49700	81.61	0.538
2	-29.914	1.23			
3	12.304	3.27	1.49700	81.61	0.538
4*	133.906	0.19			
5	9.781	3.54	1.61800	63.33	0.544
6	-30.296	0.98	1.72047	34.71	0.583
7	6.120	1.14			
8(Stop)	œ	0.73			
9` 1′	-13.763	0.70	1.90366	31.32	0.595

0			Unit mm			
			Surface dat	ta		
	Surface no.	r	d	nd	vd	$\theta \mathrm{gf}$
5	1	24.757	4.50	1.49700	81.61	0.538
	2	-20.382	0.14			
	3*	-83.898	1.15	1.53368	55.90	0.563
	4*	28.935	0.15			
	5	14.657	4.68	1.49700	81.61	0.538
_	6*	-22.520	2.49			
0	7	8.244	3.90	1.61800	63.33	0.544
	8	-18.524	0.70	1.72047	34.71	0.583
	9	6.509	1.16			
	10(Stop)	∞	1.00			
	11	-7.654	1.06	1.90366	31.32	0.595
	12	-19.862	2.42	1.61800	63.33	0.544
5	13	-14.476	0.10			
	14*	10.185	4.10	1.49700	81.61	0.538

133	130
ontinued	-continued

15* 16* 17* 18* 19* 20 21 Image plane	-13.446 22.889 -29.222 -6.641 16.877 \$\infty\$	Unit mm 0.10 3.01 5.24 0.70 3.70 0.30 0.31	1.58364 1.53368	30.30	0.599	- -	Unit mm					
16* 17* 18* 19* 20	22.889 -29.222 -6.641 16.877	3.01 5.24 0.70 3.70 0.30	1.53368		0.599	- 5						
8- F			1.51640	55.90 65.06	0.563 0.535	10	-69.652 1.69 1.61800 63.33 0 -20.000 0.10 8.145 3.21 1.49700 81.61 0 -15.000 0.95 1.51742 52.43 0 11.934 0.72).595).544).538).556).599				
		ical surfa	ce data			•).563				
<u>3r</u>	rd surface					-	∞ 0.31).535				
A	= 0.000 4 = -5.08296e-0. th surface	5, A6 = -:	5.46138e-07			15	Image plane Aspherical surface data					
k : Ad 6t	= 0.000 .4 = 1.91756e-05, th surface	, A6 = -4.	.56532e-07			_ 20	4th surface k = 0.000 A4 = 9.03821e-05 15th surface					
A- 14	= 0.000 4 = 4.28078e-05 4th surface					_	k = 0.000 A4 = -1.16458e-04 16th surface					
A	= -0.579 4 = -5.62366e-0 5th surface	7				25 -	k = 0.000 A4 = 3.05202e-04 17th surface					
A4 16	k = 0.000 A4 = 1.84420e-04 16th surface				- 30	k = 0.000 A4 = 4.25245e-04 18th surface						
A	= 0.000 4 = -4.33240e-0.7th surface	5				_	k = 0.000 A4 = -8.51966e-04, A6 = -6.89946e-06					
A	= 0.000 4 = 1.44611e-04					35	Various data					
k s	8th surface = 0.000 .4 = 2.83534e-04 9th surface					_	NA 0.15 Magnification -1.03 Focal length 9.35 Image height (mm) 4.92 fb (mm) (in air) 4.21					
	k = 0.000 A4 = -7.46747e-04, A6 = 4.74306e-06						Lens total length (mm) (in air) 34.91					
Various data					-	Example 11						
Focal le	fication length height (mm)			0.21 -1.05 9.35 4.92		45	Example 11					
fb (mm	n) (in air) otal length (mm) ((in air)		4.21 40.82			Unit mm					
							Surface data					

Example 10

		Unit mm			
		Surface da	ta		
Surface no.	r	d	nd	νd	θgf
1	20.000	3.29	1.49700	81.61	0.538
2	-27.197	0.40			
3	12.782	3.47	1.49700	81.61	0.538
4*	186.607	0.99			
5	10.290	3.50	1.61800	63.33	0.544
6	-17.388	0.86	1.72047	34.71	0.583
7	6.090	1.02			
8(Stop)	00	0.75			

		Unit mm									
Surface data											
Surface no.	r	d	nd	νd	$\theta g f$						
1	15.000	3.56	1.49700	81.61	0.538						
2	-34.400	0.10									
3	11.283	3.07	1.49700	81.61	0.538						
4*	114.633	1.10									
5	11.882	3.29	1.61800	63.33	0.544						
6	-23.894	1.08	1.72047	34.71	0.583						
7	6.254	0.98									
8(Stop)	∞	0.41									
9	28.157	0.70	1.90366	31.32	0.595						
10	12.525	1.62	1.61800	63.33	0.544						
11	29.622	4.65									
12*	19.060	2.87	1.49700	81.61	0.538						
13*	-20.715	0.10									
14	30.351	3.69	1.86400	40.58	0.567						
15	-8.760	0.84	1.56384	60.67	0.540						
16	33.363	1.93									
17*	-8.111	0.70	1.53368	55.90	0.563						
18*	20.135	3.70									

137	130
ontinued	-continued

		-continue	ed				-continued						
		Unit mm				-			Unit mm				
19	∞	0.30	1.51640	65.06	0.535	- 5		Asphe	erical surfa	ce data			
20 Image plane	& &	0.31						2nd surface					
	Asph	erical surfa	ice data			-		k = -4.214 3rd surface					
	4th surface					- _ 10	k = 0,000						
	k = 0.000 A4 = 1.82154e-0)4						A4 = 3.91871e-0: 4th surface	5, A6 = 3.1	.9948e-08			
	$\frac{12\text{th surface}}{k = -0.579}$					- 15		k = 0.000 A4 = -2.66544e-15th surface	04, A6 = 4	.29908e-08			
	A4 = -2.53743e - 13th surface k = 0.000	-05				_		k = -1.434 A4 = -1.94439e - 16 16th surface	04				
	A4 = 1.30619e-04 17th surface k = 0.000							k = -0.579 $A4 = 2.99389e-04$ 17th surface	4				
	A4 = 2.60653e-04 18th surface k = 0.000							k = 0.000 A4 = -1.11526e-1 18th surface	04				
A4 = -2.39609e - 04, $A6 = 9.46048e - 07$						25 -		k = 2.656 A4 = -2.50790e-	04				
Various data						_		19th surface					
NA 0.15 Magnification -1.03 Focal length 10.32						30	k = 0.000 A4 = 1.33117e-04 20th surface						
Im: fb (Focal length 10.22 Image height (mm) 4.92 fb (mm) (in air) 4.21 Lens total length (mm) (in air) 34.91							k = 0.000 A4 = 2.61407e-04 21th surface	4				
						- 35		k = 0.000 A4 = -4.36562e-	04				
	E	Example	12				Various data						
						40					0.18 -1.05	-1.05	
		Unit mm				_	Ima	al length ge height (mm)			7.99 4.92		
		Surface da	ta					nm) (in air) s total length (mm)	(in air)		2.77 34.88		
Surface no.	r	d	nd	\mathbf{v} d	$\theta g f$	45							
1 2*	96.073 -18.251	2.73 0.30	1.84666	23.77	0.620	-		Е	xample	13			
3* 4*	-23.375 10.401	0.50 0.30	1.58364	30.30	0.599								
5 * 6	9.515 -32.363	3.87 0.10	1.49700	81.61	0.538	50			Unit mm				
7	10.328	3.78	1.49700	81.61	0.538								
8 9	-34.714 10.969	0.30 2.74	1.61800	63.33	0.544		-		Surface dat				
10 11	-26.411 5.686	0.61 1.34	1.72047	34.71	0.583		Surface no.	r	d	nd	νd	θgf	
2(Stop)	œ	0.30				55	1	47.665	2.51	1.84666	23.77	0.620	
.3 .4	15.413 9.057	0.50 1.61	1.72047 1.61800	34.71 63.33	0.583 0.544		2* 3*	-21.643 -78.703	0.30 0.50	1.58364	30.30	0.599	
.5	9.689	1.83					4*	8.889	0.30				
6*	9.565 340.758	2.26 1.70	1.49700	81.61	0.538		5* 6	8.817 -86.120	3.03 0.10	1.49700	81.61	0.538	
7*	11.503	2.38	1.63490	23.88	0.630	60	7	-86.120 9.186	3.18	1.49700	81.61	0.538	
		3.01					8	-23.055	0.30				
.8* .9*	1563.756			55.00	0.563		9	12.987	2.57	1.61800	63.33	0.544	
18* 19* 20*	-5.590	1.96	1.53368	55.90	0.000		10	-22 422	0.87				
18* 19* 20* 21* 22	-5.590 57.014 ∞	1.96 2.21 0.38	1.53368 1.51640	65.06	0.535		10 11	-22.422 5.211	0.87 0.94	1.72047	34.71	0.583	
17* 18* 19* 20* 21* 22 23 Image plane	-5.590 57.014	1.96 2.21				65							

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-continued		

		·commue	Z.u				-continued						
	Unit mm							Unit mm					
15 16* 17* 18*	11.556 11.244 5498.309 8.310 32.497	3.60 2.21 2.42 2.64 2.45	1.49700 1.63490	81.61 23.88	0.538	5	4* 5* 6 7 8	8.30 8.00 -27.83 12.33 -15.00	22 4.21 21 0.10 14 3.81	1.49700 1.49700	81.61 81.61	0.538 0.538	
20* 21* 22 23 mage plane	−8.166 18.771 ∞ ∞	0.75 2.20 0.38 0.31	1.53368 1.51640	55.90 65.06	0.563	10	9 10 11 12(Stop)	15.82 −16.60 5.92 ∞	0.86	1.61800 1.72047	63.33 34.71	0.544 0.583	
ge Prime		erical surfa	ice data			-	13 14	19.83 8.70		1.59542	57.26	0.547	
	2nd sur					- 15	15* 16*	30.11 -129.4		1.49700	81.61	0.538	
	k = -3.0 3rd surf						17* 18* 19*	11.1′ 69.85 -11.75	54 2.52	1.63490 1.53368	23.88 55.90	0.630	
	k = 0.00 A4 = -3 4th surf	3.60571e-0)5			20	20* 21 22 Image pla	28.33	21 2.45 0.38 0.30	1.51640	65.06	0.535	
	k = 0.00 $A4 = -1$)0 1.12816e-(04				-	A	Aspherical surfa	ace data			
	5th surf					- 25		<u>2n</u>	d surface				
	k = -0.9 $A4 = -3$ $16th sum$	7.73645e-()5			_ 23			= -6.782 d surface				
	k = -0.5 A4 = 7. 17th sur	09702e-04	1			30		A4	= 0.000 4 = -1.06326e- n surface	04			
	k = 0.00 A4 = 5. 18th sur	12138e-04	1			_		A4	= 0.000 4 = -4.80995e- 1 surface	04			
	k = -0.1 $A4 = -2$ $19th sun$	2.01937e-0	06			35 –		A4	= -1.297 4 = -2.89846e- th surface	04			
	k = 0.00 $A4 = -3$ $20th sun$	3.03025e-0	07			_ 40		A4	= -0.579 4 = -2.76313e- th surface	06			
	k = 0.00 A4 = 1. 21th sur	53947e-06	5			_		A4	= 0.000 4 = 4.96403e-0	6			
	k = 0.00 $A4 = -1$)() 1.55823e-(06			45			th surface				
		Various da				-		A4	= 1.101 4 = -1.96685e- th surface	05			
Foc. Ima	gnification al length ge height(mm)			0.13 -1.05 8.59 4.92		50		A4	= 0.000 1 = 9.87207e-0 th surface	6			
fb(mm) (in air) 2.76 Lens total length(mm) (in air) 33.88 Example 14								A4	= 0.000 4 = 8.51271e-0 th surface	6			
									= 0.000 1 = -2.32962e-	05			
Unit mm									Various da	ıta			
	Unit mm Surface data							NA Magnification		<u> </u>	0.14 -1.05		
Surface no.	r	d	nd	νd	θgf	-		Focal length Image height(n			9.49 4.92		
1 2* 3*	47.850 -22.343 -42.136	2.59 0.30 0.50	1.84666 1.58364	23.77 30.30	0.620 0.599	65		fb(mm) (in air) Lens total lengt			3.00 35.87		

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							Unit mm						
Unit mm Surface data						- 5	21th surface						
						-		k = 0.000 A4 = -2.39642e-04, A6 = -9.62165e-07					
Surface no.	r	d	nd	νd	θgf	_			Various da				
1* 2*	17.425 26.052	1.99 2.15	1.84666	23.77	0.620	10		NA.			0.21		
3	78.603 -23.793	2.65 0.10	1.49700	81.61	0.538			Magnification Focal length			-1.05 8.84		
5 6*	20.854 -28.805	2.93 0.97	1.49700	81.61	0.538		Image height(mm) 4.92 fb(mm) (in air) 3.21						
7	10.233	3.22	1.61800	63.33	0.544	15							
8 9	-14.403 6.263	0.70 1.54	1.72047	34.71	0.583								
10(Stop) 11	∞ -23.449	2.59 1.10	1.90366	31.32	0.595								
12	23.820	4.50	1.61800	63.33	0.544	20	Example 16						
13 14*	-13.224 20.191	0.10 4.92	1.49700	81.61	0.538	20							
15*	-12.021	2.06											
16* 17*	16.842 -61.090	2.97 2.44	1.58364	30.30	0.599		Unit mm						
18*	-13.902	0.70	1.49700	81.61	0.538	25	Surface data						
19* 20*	22.930 -7.006	2.41 0.70	1.53368	55.90	0.563	25	Surface no.	r	d	nd	νd	θgf	
21* 22	42.359 ∞	2.70 0.30	1.51640	65.06	0.535		1*	44.490	2.90	1.84666	23.77	0.620	
23 Image plane	8	0.31					2* 3	1042.481 32.397	0.10 3.52	1.49700	81.61	0.538	
	Aspher	ical surfa	ce data			- 30	4 5	-23.206 14.648	0.10 3.55	1.49700	81.61	0.538	
1st surface k = 0.000 A4 = 1.14998e-04					-	6 * 7	-33.420 11.152	0.10 3.61	1.61800	63.33	0.544		
					-	8 9	-8.805 5.456	0.70 0.96	1.72047	34.71	0.583		
					35	10(0)	∞ -9.368	0.72 0.70	1.90366	31.32	0.595		
2nd s	surface					_	12	58.101	4.03	1.61800	63.33	0.544	
k = 0	.000						13 14*	-11.863 22.578	1.16 4.50	1.49700	81.61	0.538	
	1.87722e-04 urface						15* 16*	-10.017 33.644	1.59 3.89	1.58364	30.30	0.599	
our se	urrace					_ 40	17*	-23.118	5.88				
k = 0							18* 19*	-8.960 13.998	0.70 3.70	1.53368	55.90	0.563	
	7.02747e-05 surface						20	∞	0.30	1.51640	65.06	0.535	
k = -	0.579						21 Image plane	&	0.31				
A4 =	A4 = -8.56059e-05 15th surface					45	Aspherical surface data						
k = 0						_		1st surface					
A4 = 16th						k = 0.000 A4 = 9.48776e-00 2nd surface	5						
	.000 6.70751e-05 surface					_		k = 0.000 A4 = 1.31636e-04 6th surface	4				
	.000 3.13794e-05 surface					55 -		k = 0.000 A4 = 4.63529e-03 14th surface	5				
	.000 3.45712e-04 surface					_ 60		k = -0.579 $A4 = -8.09511e^{-1}$ 15th surface	05				
	.000 3.55414e-04 surface					_		k = 0.000 A4 = 1.88059e-03 16th surface	5				
k = 0 A4 =	.000 2.17628e-04					65		k = 0.000 A4 = -7.81147e - 0.000	05				

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k = 0.000 A4 = -8.95475e-04, A6 = -1.08381e-05

	-	143 continue	ed					-0	144 continue	ed			
		Unit mm							Unit mm				
	17th surface					 - 5	161	h surface					
	k = 0.000 A4 = -1.26355e-18th surface	05				_	A4	k = 0.000 A4 = 1.82606e-04 17th surface					
	k = 0.000 A4 = 2.75080e-0-	4				10		k = 0.000 A4 = -4.51042e-04, A6 = -1.53697e-06					
	19th surface k = 0.000							V	arious da	ta			
	$A4 = -4.02076e^{-1}$	04, A6 = 6	.67549e-07				NA Magnification				0.20 -1.05		
1	NA	Various da	ta	0.18		15	Focal Imag	length e height(mm) n) (in air)			10.21 4.92 4.21		
I	Magnification Focal length mage height(mm)			-1.05 10.48 4.92		-	Lens	total length(mm) (in air)		40.13		
f	b(mm) (in air) Lens total length(mr	n) (in air)		4.21 42.91		20		Ex	cample	18			
	E	xample	17										
		1				25			Unit mm				
								S	urface da	ta			
	Unit mm Surface data						Surface no.	r	d	nd	νd	$\theta g f$	
Surface no.	r	d d	nd	vd	θgf	30	1 2	20.000 -21.403	3.41 0.10	1.49700	81.61	0.538	
1	30.001	3.55	1.49700	81.61	0.538	-	3 4*	10.837 419.463	2.84 0.10	1.49700	81.61	0.538	
2 3	-20.144	0.10	1 40700	01.61			5 6	29.618	2.52	1.61800	63.33	0.544	
<i>4</i> *	14.839 -204.753	2.95 1.38	1.49700	81.61	0.538	35	7	-14.040 9.509	0.70 3.36	1.72047	34.71	0.583	
5	9.541	3.61	1.61800	63.33	0.544	33	8(Stop)	∞	0.20				
6	-22.503	0.94	1.72047	34.71	0.583		9	15.000	0.70	1.59551	39.24	0.580	
7 8(Stop)	5.977 ∞	1.25 1.09					10 11	4.665 14.569	2.31 0.75	1.64769	33.79	0.594	
9	-7.570	1.76	1.90366	31.32	0.595		12*	18.814	2.92	1.49700	81.61	0.538	
.0	-16.099	2.78	1.61800	63.33	0.544		13*	-8.306	0.10	1.42700	01.01	0.550	
.1	-10.217	0.10				40	14	-27.184	4.50	1.86400	40.58	0.567	
.2*	11.695	5.99	1.49700	81.61	0.538		15	-13.984	0.80				
3*	-15.540	1.31					16	-10.364	2.42	1.56384	60.67	0.540	
.4*	26.431	2.57	1.58364	30.30	0.599		17	42.568	2.09				
5*	405.879	5.84	1 52270	55.00	0.563		18*	-4.588 17.205	0.88	1.53368	55.90	0.563	
.6* .7*	-6.493 676.071	0.70 3.70	1.53368	55.90	0.563	45	19* 20	-17.205 ∞	3.70 0.30	1.51640	65.06	0.535	
.8	o/0.0/1	0.30	1.51640	65.06	0.535		21	∞	0.31	1.510-0	05.00	0.555	
.9 mage plane	8 8	0.31	1101010	00.00	0,000		Image plane	œ	0.01				
mage plane		erical surfa	ce data					Asphei	rical surfa	ice data			
	4th surface					- 50	<u>4th</u>	surface					
	k = 0.000 A4 = 5.71106e-0	5				_	A4	: 0.000 -= 1.96955e–04 h surface					
	12th surface k = -0.579 A4 = 1.53768e-0.13th surface	5				55	A4	= -0.579 = 1.16008e-04 th surface					
	13th surface k = 0.000 A4 = 6.02131e-0: 14th surface	5				60	A4	0.000 = 6.10145e-04 h surface					
	k = 0.000 $A4 = -8.63826e - 15$ th surface	05				_	A4 191	0.000 = 5.15864e-04 th surface : 0.000					

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k = 0.000 A4 = -5.74333e-05

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Unit mm Unit Various data 5 20th surface NA 0.15 k = 0.000 Magnification -1.04 A4 = 3.84196e-05 Focal length 8.63 21th surface Image height(mm) 4.92 21th surface fb(mm) (in air) 4.21 k = 0.000 Lens total length(mm) (in air) 34.91 10 A4 = 6.16533e-05 22th surface	mm		
NA 0.15 Magnification -1.04 Focal length 8.63 Image height(mm) 4.92 fb(mm) (in air) 4.21 Lens total length(mm) (in air) 34.91 10 k = 0.000 k = 0.000 k = 0.000 A4 = 6.16533e-05 22th surface			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			
Example 19			
Unit mm $A4 = -6.49627e - 05$ 24th surface			
Surface data 20 k = 0.000			
Surface no. r d nd vd θ gf $ A4 = -5.07397e - 05 $ 25th surface			
1 15.792 2.15 1.60999 27.48 0.620 2 23.978 0.00 1001.00000 -3.45 0.296 k = 0.000 3 23.978 0.20 1.63762 34.21 0.594 4 23.780 2.78	5 = 1.30476e-06	5	
5* 14.045 4.50 1.49700 81.61 0.538 Variou 6 -93.714 0.10	ıs data		
7 12.954 2.81 1.49700 81.61 0.538 NA 8* 48.862 0.93 9 27.146 2.74 1.61800 63.33 0.544 Magnification		0.15 -1.00	
10 -13.584 0.73 1.72047 34.71 0.583 30 Focal length 11 18.090 1.34 Image height(mm) 12(Stop) 0.02 fb(mm) (in air)		9.02 4.92 1.75	
13 13.257 0.72 1.90366 31.32 0.595 Lens total length(mm) (in 14 5.010 1.34 1.61800 63.33 0.544 15 8.118 0.75	air)	42.28	
16* 6.148 2.11 1.49700 81.61 0.538 35 17* 10.525 2.08 18* -7.323 3.11 1.49700 81.61 0.538 Example*	ple 20		
20* 14.481 3.56 1.58364 30.30 0.599 21* -16.233 1.90 22* -12.939 0.71 1.49700 81.61 0.538 40			
23* 41.071 4.34 Unit 24* -7.245 0.70 1.53368 55.90 0.563	mm		
25* 54812.275 1.21 Surfac 26	e data		
	d nd	νd	$\theta \mathrm{gf}$
45 1* 32.834 2.	51 1.84666 74	23.77	0.620
3* -13.08 0.0 5th surface 4* 10.024 0.	70 1.58364	30.30	0.599
	69 1.49700 16 75 1.61800	81.61 63.33 34.71	0.538 0.544 0.583
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	17 16 89 1.72047	34.71	0.583
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	10 45 1.49700 10	63.33 81.61	0.544
A4 = -4.12749e - 05 19* -39.253 5.0	09 00 1.63490	81.61 23.88	0.538
18th surface 20* -5.955 0.	22	55.90 55.90	0.563 0.563
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	20 38 1.51640	65.06	0.535
$k = 0.000$ 65 Image plane ∞ A4 = 5.26452e-05			

148 Example 21

Aspherical surface data	5			Unit mm			
1st surface			S	urface dat	ta		
k = 0.000 A4 = 1.50492e-04, A6 = -3.54780e-06	_	Surface no.	r	d	nd	νd	θ
2nd surface		1* 2*	37.191 -60.365	2.51 0.10	1.84666	23.77	0.6
k = -2.669 A4 = 2.22005e-04, A6 = -2.69213e-06		3* 4*	45.462	0.70	1.58364	30.30	0.:
3rd surface		5*	17.208 14.316	0.10 4.65	1.49700	81.61	0.
k = 0.000		6 7	-53.760 23.156	0.10 3.55	1.49700	81.61	0.
A4 = 3.10091e-04 4th surface	15	8* 9	-23.670 22.799	0.10 2.41	1.61800	63.33	0.
k = 0.000		10	-29.442	0.70	1.72047	34.71	0.
A4 = -3.25978e-04		11 12 (Stop)	7.650 ∞	1.45 1.07			
5th surface	20	13 14	-25.486 7.699	0.70 2.32	1.72047 1.61800	34.71 63.33	0. 0.
k = -1.313 A4 = -2.31327e-04, A6 = 3.63551e-06	20	15	50.679	0.10			
6th surface		16* 17*	12.228 98.730	2.01 16.81	1.49700	81.61	0.
k = -1.763		18* 19*	31.846 -77.563	6.30	1.49700	81.61	0.
A4 = 1.38063e-04, A6 = -2.69269e-07 14th surface	25	20*	14.198	2.03 3.25	1.63490	23.88	0.
		21* 22*	201.898 -12.028	4.35 0.70	1.53368	55.90	0.
k = -0.579 A4 = 1.44838e-04, A6 = -1.01594e-06		23*	20.065	1.37			
15th surface		24* 25*	34.840 16.829	0.70 1.23	1.53368	55.90	0.
k = 0.000	30	26 27	00	0.38	1.51640	65.06	0.
A4 = 2.79291e-04, A6 = -6.60640e-07 16th surface	_	Image plane	8	0.30			
k = 0,000			Asphe	rical surfa	ce data		
A4 = 1.42801e-04, A6 = 2.79003e-07 17th surface	35		1st su	face			
k = 0,000			k = 0.0				
A4 = -1.94371e-04, A6 = 1.98964e-06 18th surface			$A4 = -\frac{2}{2}$ and su	-2.94380e irface	e=05		
k = -2.995	40		k = -3	2.935 5.14622e-	06		
A4 = 2.02338e-04, A6 = -3.03901e-06 19th surface			3rd su		-00		
k = 0.000			k = 0.0	000 -1.75346e	-07		
A4 = 3.16281e-04, A6 = -2.16676e-06			4th su				
20th surface	45		k = 0.0	000			
k = 0.000 A4 = 1.23235e-03			A4 = - 5th su	-4.72517e rface	-05		
A4 = 1.25253e-05 21th surface							
k = 0.000	50		k = -0 A4 = -	.524 -1.41649e	e-05		
A4 = 7.37586e - 04	30		8th su	rface			
22th surface			k = -7		05		
k = 0.000 A4 = 1.78231e-04			A4 = 1 16th s	l.22953e- urface	-03		
23th surface	55		k = -0	.579			
k = -207.247	_			2.95007e-	-05		
A4 = -9.71403e-04, A6 = -5.03108e-06			k = 0.0				
Various data	60			-2.68357e	e-05		
JA 0.23							
Magnification -1.33 Focal length 5.76			k = 0.0 $A4 = 0$	000 5.31745e-	-05		
mage height (mm) 4.92			19th s	urface			
b (mm) (in air) 1.75							

		-contin	ued				-continued	
		Unit m	m				Unit mm	
	20th	surface				- - 5	Aspherical surface data	1
	A4	0.000 = 6.62069 1 surface	e-06				1st surface	
	A4	0.000 = -5.8151 1 surface	.6e-05			10	k = 0.000 A4 = 4.20748e-06 2nd surface	
	A4	0.000 = 1.13853 1 surface	e-04			_	k = 0.000 A4 = 1.02174e-05 5th surface	
	A4	0.000 = -1.7015 i surface	51e-04			15	k = 0.362 A4 = -1.39316e-06 8th surface	
	A4	0.000 = -3.4650 1 surface	08e-04			20	k = 0.000 A4 = 7.34221e-05 16th surface	
		0.000 = -8.4032 Various o				_	k = -0.579 A4 = -1.11345e-04 17th surface	
N F In	IA Magnification ocal length mage height (mm)			0.23 -1.33 11.95 4.92		_ 25	k = 0.000 A4 = -3.97260e-04 18th surface	
	o (mm) (in air) ens total length (r	nm) (in ai	ir)	1.78 59.87		30 -	k = 0.000 A4 = 3.14959e-04 19th surface	
]	Exampl	e 22			35	k = 0.000 A4 = 9.18979e-04 20th surface	
		Unit m	m			- -	k = 0.000 A4 = -3.01972e-04 21th surface	
		Surface of	data			40	k = 0.000	
Surface no.	r	d	nd	νd	θgf	_	A4 = 1.22286e-04 22th surface	
1* 2* 3	19.718 57.140 28.082	2.47 0.10 0.70	1.84666 1.65412	23.77 39.68	0.620 0.574	45	k = 0.000 A4 = 3.61097e-10	
4 5* 6	15.535 16.135 -111.432	0.71 3.81 0.10	1.49700	81.61	0.538		23th surface k = 0.000	
7 8* 9 10	12.560 9264.110 23.767 -17.820	3.28 0.10 2.95 0.70	1.49700 1.61800 1.72047	81.61 63.33 34.71	0.538 0.544 0.583	50	A4 = -2.33784e-10 24th surface	
11 12 (Stop) 13 14	14.919 ∞ 36.855 6.199	0.94 -0.22 0.70 2.19	1.90366 1.61800	31.32 63.33	0.595 0.544		k = 0.000 A4 = 7.88303e-11 25th surface	
15 16* 17*	13.800 7.064 -1661.525	0.10 3.86 5.38	1.49700	81.61	0.538	55	k = 0.000 A4 = -9.83303e-04, A6 = -4.8076	58e-06
18* 19* 20*	-7.343 26.316 14.001	0.70 2.07 4.50	1.49700 1.58364	81.61 30.30	0.538		Various data	
20* 21* 22*	-8.579 -9.265	4.50 3.08 0.70	1.49700	81.61	0.599	60	NA	0.23
23* 24* 25*	10.893 -15.074 -20.788	2.23 1.42 0.76	1.53368	55.90	0.563		Magnification Focal length Image height (mm)	-1.33 9.09 4.92
26 27 Image plane	8 8 8	0.38 0.30	1.51640	65.06	0.535	65	fb (mm) (in air) Lens total length (mm) (in air)	1.31 43.88

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							Unit mm						
		Unit m	m			- 5	24th surface						
		Surface	data			_		k = 0.000 A4 = -4.02512e-11	ı				
Surface no.	r	d	nd	νd	θgf	_		25th surface					
1	21.347	0.70	1.83400	37.16	0.577	- 10		k = 0.000 A4 = 1.98197e-11					
2 3	19.857 82.525	2.68 0.10	1.84666	23.77	0.620			26th surface					
4 5	28.223 13.598	0.70 0.10	1.65412	39.68	0.574			k = 0.000					
6*	13.218	4.13	1.49700	81.61	0.538			A4 = -7.91121e - 04	4, A6 = -7	7.74500e-06			
7 8	-426.276 12.661	0.10 3.24	1.49700	81.61	0.538	15		V	arious data	a			
9* 10	-620.123 23.276	0.10 3.03	1.61800	63.33	0.544			NA			0.23		
11	-15.973	0.70	1.72047	34.71	0.583			Magnification			-1.33		
12	14.351	0.94						Focal length			8.95		
3 (Stop)	∞	-0.12						Image height (mm)			4.92		
4	52.229	0.70	1.90366	31.32	0.595	20		fb (mm) (in air)	\ (im aim)		2.12		
.5	6.517	2.05	1.61800	63.33	0.544			Lens total length (mm) (in air)		44.87		
.6	14.011	0.10											
7*	7.279	3.70	1.49700	81.61	0.538								
8*	-52.147	6.22						Ex	omalo 3	14			
.9*	-8.485	0.70	1.49700	81.61	0.538			EX	ample 2	. 4			
20*	18.496	2.19				25							
21*	16.238	3.38	1.58364	30.30	0.599								
22*	-8.208	3.48	1.50501	30.30	0.000								
23*	-14.030	0.80	1.49700	81.61	0.538			1	Unit mm				
24*	10.694	2.34	1.45700	01.01	0.550			·	Omt mm				
. !5*	-13.561	0.70	1.53368	55.90	0.563			Su	ırface data	ı			
			1.55506	33.90	0.505	30							
6*	-32.525	1.56	1.51.640	65.06	0.535		Surface no.	r	d	nd	vd	θ gf	
7	∞	0.38	1.51640	65.06	0.535								
8 mage plane	∞ ∞	0.30					1*	29.347	3.01	1.84666	23.77	0.620	
mage plane						_	2*	-36.004	0.10		• • • • •		
	Aen	herical sui	rface data				3	-397.741	0.70	1.65412	39.68	0.574	
	r top	nerieur sur	nace data			35	4	21.124	0.10	1 10700	01.61	0.530	
	6th surface						5*	19.426	4.27	1.49700	81.61	0.538	
	om surface					_	6	-31.982	0.10	1 40700	01.61	0.530	
	k = 0.102						7 8*	20.342	3.53	1.49700	81.61	0.538	
		0.0						-22.961	0.10	1 (1000	(2.22	0.544	
	A4 = -3.11348e	-00					9	-172.666	2.93	1.61800	63.33	0.544	
	9th surface					40	10 11	-11.505	0.70	1.72047	34.71	0.583	
								24.226 ∞	0.79 0.17				
	k = 0.000						12 (Stop) 13	-243.374	0.17	1.90366	31.32	0.595	
	A4 = 7.09963e -	05					13	9.660	3.41		63.33	0.544	
	17th surface						15	-43.351	0.10	1.61800	05.55	0.544	
							16*		4.50	1.40700	91.61	0.539	
	k = -0.579					45		11.180 -10186.757	4.30 8.48	1.49700	81.61	0.538	
	A4 = -1.62833e	-04					18*	719.997	0.70	1.49700	81.61	0.538	
	18th surface						19*	13.006	6.32	1.77/00	01.01	0.556	
							20*	13.192	3.44	1.58364	30.30	0.599	
	k = 0.000						21*	-15.080	3.70	1.50504	50.50	0.000	
	A4 = -2.59299e	-04					22*	-9.430	0.81	1.49700	81.61	0.538	
	19th surface					50		10.877	2.39	2.12/00	01.01	5.550	
	-						24*	-10.747	0.51	1.53368	55.90	0.563	
	k = 0.000						25*	-3339.876	1.95	1.55500	22.50	0.000	
	A4 = 2.69659e -	05					26	∞	0.38	1.51640	65.06	0.535	
	20th surface	0.0					27	∞	0.30	110 10 10	05.00	0.000	
	20th bulliage					_	Image plane	∞					
	k = 0.000					55							
	A4 = 5.59803e -	∩4				33		Aspheri	cal surfac	e data			
	21th surface	•											
						_		1st surface					
	k = 0.000							1 0.000					
	A4 = -2.63419e	-04						k = 0.000					
	22th surface	*				60		A4 = 1.00145e-05					
						_		2nd surface					
	k = 0.000							k = 0.000					
	A4 = 1.85257e -	04						A4 = 4.66734e - 05					
	23th surface							5th surface					
						_		Jan Janiace					
	k = 0.000					65		k = 0.699					
	A4 = 1.30466e-	10						A4 = 2.24508e - 05					

		153							154			
		-contin	ued			_			-contin	ued		
		Unit n	ım			_			Unit m	ım		
	8th surface k = 0.000 A4 = 8.05284e- 16th surface	-05				- 5	12 (Stop) 13 14 15 16*	213.328 9.662 -95.685 11.359	0.42 0.70 3.29 0.10 4.50	1.90366 1.61800 1.49700	31.32 63.33 81.61	0.595 0.544 0.538
	k = -0.579 A4 = 7.50799e- 17th surface	-06				10	17* 18* 19* 20*	192.634 -46.287 55.888 15.242	12.20 0.70 3.89 3.43	1.49700 1.58364	81.61	0.538
	k = 0.000 $A4 = -8.039286$ 18th surface	e-05				_	21* 22* 23* 24*	-12.872 -9.883 10.330 -8.858	3.53 0.70 2.47 0.47	1.49700 1.53368	81.61 55.90	0.538 0.563
	k = 0.000 A4 = -2.620426 19th surface	e-04				15	25* 26 27 Image plane	38.821	2.50 0.30 0.30	1.51640	65.06	0.535
	k = 0.000					_		Asp	herical su	rface data		
	A4 = 2.02927e- 20th surface	-08				20		1st surface				
	k = 0.000 A4 = 1.22996e- 21th surface	-05				_		k = 0.000 $A4 = -8.608556$ 2nd surface	e−06			
	k = 0.000 A4 = 1.31433e- 22th surface	-04				25		k = 0.000 A4 = 5.67857e- 5th surface	-05			
	k = 0.000 A4 = 1.29005e- 23th surface	-10				30		k = -0.732 A4 = 8.88649e- 8th surface	-05			
	k = 0.000 A4 = -8.961646 24th surface				_		k = 0.000 A4 = 9.71863e- 16th surface	-05				
	k = 0.000 A4 = 3.63415e- 25th surface	-11				35		k = -0.579 A4 = 3.62332e- 17th surface	-05			
	k = 0.000 $A4 = -8.063026$			-06		- 40		k = 0.000 $A4 = -4.683596$ 18th surface	e−05			
	NA Magnification	Various	data	0.38 -2.20		-		k = 0.000 A4 = -3.905966 19th surface	e-04			
	Focal length Image height (mm fb (mm) (in air) Lens total length (ir)	5.02 4.92 2.50 54.08		45		k = 0.000 A4 = 5.65832e- 20th surface	-09			
		Exampl	e 25			50		k = 0.000 A4 = 1.29627e- 21th surface	-04			
								k = 0.000 A4 = 2.61604e- 22th surface	-04			
		Unit m Surface				-		k = 0.000				
Surface no.	r	d	nd	vd	θgf	_ 55		A4 = 6.73337e- 23th surface	-11			
1* 2* 3	32.463 -21.826 -115.439	2.90 0.10 0.70	1.84666 1.65412	23.77	0.620 0.574	-		k = 0.000 A4 = -2.859356 24th surface	e-10			
4 5* 6 7	19.615 22.162 -24.111 34.797	0.71 3.86 0.10	1.49700	81.61	0.538	60		k = 0.000 A4 = -1.783746 25th surface	÷-11			
8* 9 10	-16.663 -45.805 -9.473	3.13 0.10 3.04 0.70	1.49700 1.61800 1.72047	81.61 63.33 34.71	0.538 0.544 0.583	65		k = 0.000 $A4 = -1.178076$	e-03, A 6 =	1.38777e-	-06	
11	97.538	0.68										

1.00	15
ntinued	-conti

	-c	ontinue	ed					-0	continue	rd		
		Unit mm						out 6	Unit mm			
		arious dat	I.a.			_ 5	_	8th surface				
Foc	agnification cal length age height (mm)			0.43 -2.55 4.06 4.92			A	= 0.000 A4 = -9.44986e 9th surface	-05			
fb ((mm) (in air) ns total length (mm	ı) (in air)		3.00 55.41		10	A	= 0.000 A4 = 2.20099e- 0th surface	08			
	Ex	ample :	26				Α	t = 0.000 A4 = -2.09970e 1th surface	-04			
						15	A	t = 0.000 A4 = 1.31063e-1 2th surface	04			
		Unit mm				_	_	= 0.000				
	S	urface dat	ta			- 20	Α	$A4 = -4.92137e^{-4}$	-11			
Surface no	o. r	d	nd	\mathbf{v} d	θgf		_	3th surface				
1* 2*	35.723 -51.097	2.54 0.10	1.84666	23.77	0.620	-	Α	t = 0.000 A4 = -3.04317e 4th surface	-10			
3 4 5*	36.176 20.906 23.037	0.71 0.70 3.88	1.65412 1.49700	39.68 81.61	0.574	25		t = 0.000 $t = -4.31877e$	-12			
6 7	-48.688 28.972	0.10 4.09	1.49700	81.61	0.538		2	5th surface				
8* 9 10	-14.465 -30.479 -11.008	0.10 2.71 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583	30 🕳		t = 0.000 A4 = -1.03058e	-03, A6 =	-5.12548e-	-06	
11 12(Stop)	-45.001 ∞	0.00 0.36				_		V	arious da	a		
13 14	142.278	0.70	1.90366	31.32	0.595	_	NA				0.40	
15	7.974 42.037	3.29 0.10	1.61800	63.33	0.544		Focal				-2.55 4.53	
16* 17* 18*	9.420 50.449 -10.686	4.50 11.08 0.70	1.49700 1.49700	81.61 81.61	0.538	35	fb (mr	height (mm) n) (in air) otal length (mn	ı) (in air)		4.92 1.71 51.12	
19* 20*	14.658 8.921	2.13 3.26	1.58364	30.30	0.599	-						
21* 22* 23*	-11.441 -6.836 17.063	2.20 0.70 2.85	1.49700	81.61	0.538	40		Ex	ample :	27		
24* 25*	-7.530 -23.262	1.89 1.20	1.53368	55.90	0.563							
26 27	8	0.30 0.31	1.51640	65.06	0.535	-			Unit mm			
Image plan		0.01				_ 45			urface dat	.0		
	Aspher	rical surfa	ce data				Surface no.	r	d	nd	vd	θgf
	1st surface						1*	35.661	2.32	1.84666	23.77	0.620
	k = 0.000 A4 = 2.15858e-	05				50	2* 3*	-73.499 34.183	0.43 4.48	1.49700	81.61	0.538
	2nd surface k = 0.000					_	4 5 6*	-54.877 25.768 -15.284	0.10 4.00 0.10	1.49700	81.61	0.538
	A4 = 5.89518e-6 5th surface	05				_	7 8 9	-32.854 -10.053 -46.051	2.97 0.70 0.05	1.61800 1.72047	63.33 34.71	0.544 0.583
	k = 1.031 A4 = 4.92091e-0 8th surface	05				55	10(Stop) 11 12	635.573 8.195	0.47 0.70 3.10	1.90366 1.61800	31.32 63.33	0.595 0.544
	k = 0.000 A4 = 1.43893e-	04					13 14* 15*	42.918 9.414 63.321	0.10 4.50 11.58	1.49700	81.61	0.538
	16th surface					- 60	16* 17*	-9.781 27.718	0.70 2.51	1.49700	81.61	0.538
							18*	9.851	3.31	1.58364	30.30	0.599
	k = -0.579 $A4 = 1.23991e^{-0.00}$ 17th surface	05					19* 20*	-11.040 -7.575	2.20 0.70	1.49700	81.61	0.538

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		Jnit mm				-								
24 25	& &	0.30 0.31	1.51640	65.06	0.535	5			Unit m	m				
nage plane		0.31					Surface data							
	Aspheri	cal surfac	ce data			-	Surface no.	r	d	nd	vd	θgi		
	1st surface					- _ 10	1*	26.126	2.52	1.84666	23.77	0.62		
	k = 0.000						2* 3*	156.726 19.398	0.44 3.22	1.49700	81.61	0.53		
	A4 = 3.30814e - 0 2nd surface	5					4 5	668.362 22.441	0.10 4.29	1.49700	81.61	0.53		
						_	6 * 7	-18.521 -32.011	0.10 3.31	1.61800	63.33	0.54		
	k = 0.000					15	8	-10.629	0.70	1.72047	34.71	0.54		
	A4 = 7.07042e - 0	-5					9	-32.981	-0.18					
	3rd surface					_	10(Stop)	∞	0.91					
	k = 7.049						11	-54.468	0.70	1.90366	31.32	0.59		
	A4 = 5.92848e - 0	15					12 13	10.084	3.88 5.09	1.61800	63.33	0.54		
	6th surface	_				20	14*	-38.832 11.830	4.50	1.49700	81.61	0.53		
	our surface					_ 20	15*	32.748	6.33	1.49700	61.01	0.55		
	k = 0.000						16*	-51.536	0.70	1.49700	81.61	0.53		
	A4 = 1.66928e - 0	4					17*	-5076.695	1.50					
	14th surface						18*	16.498	4.50	1.58364	30.30	0.59		
						_	19*	-18.479	2.95		_			
	k = -0.579					25	20*	-13.897	0.70	1.49700	81.61	0.53		
	A4 = 1.76892e - 0	5					21*	14.288	2.43	1.522.60	55.00	0.54		
	15th surface					_	22* 23*	-9.910	0.50 1.20	1.53368	55.90	0.56		
						_	24	19.020 ∞	0.30	1.51640	65.06	0.53		
	k = 0.000						25	∞	0.31	1.51040	03.00	0.55		
	A4 = -1.15869e	.04				20	Image plane	∞	0.51					
	16th surface					_ 30		Asn	herical su	rface data				
	k = 0.000 A4 = -1.90405e						1st surface	neriear su	Tace data					
	A4 = -1.90405e-04 17th surface					_								
	A4 = -1.90405e - 04					35		k = 0.000 A4 = 4.45476	ie_05					
								A4 = 4.43470 2nd surface	e-03					
	18th surface					_								
	1- 0.000							k = 0.000						
	k = 0.000	0.4						A4 = 4.21609	e-05					
	A4 = -1.26564e - 19th surface	····				40		3rd surface						
	k = 0.000							k = 1.630						
	A4 = 2.29008e - 0	14						A4 = -6.6863	1e-05					
	20th surface							6th surface						
	1 0.000					- 45		k = 0.000						
	k = 0.000	12						A4 = 1.02748	e-04					
	A4 = -5.43091e - 21th surface	12						14th surface						
						_		k = -0.579						
	k = 0.000							A4 = -5.9592	3e-05					
	A4 = -1.28275e	10				50		15th surface						
	22th surface					_		k = 0.000						
	l- 0.000							K = 0.000 $A4 = -1.9231$	1e_04					
	k = 0.000	1.1						A4 = -1.9231 16th surface	10-04					
	A4 = -4.59881e- 23th surface	11						Tom surface						
	25th surface					- 55		k = 0.000						
	k = 0.000							A4 = -2.6071	2e-04					
	A4 = -1.00347e	·03. A6 =	-7.29887e-	-06				17th surface						
						-		k = 0.000						
	Va	rious dat	а					A4 = 3.61925	e-09					
						60		18th surface						
				0.40										
NA	10			-2.55				k = 0.000						
Mag	nification													
Mag Foca	al length			4.30				A4 = 6.14546	ie-07					
Mag Foca Imag	al length ge height (mm)			4.92				A4 = 6.14546 $19th surface$	ie-07					
Mag Foca Imag fb (n	al length					65			ie-07					

		-contin	ued				-continued						
		Unit m	ım						Unit mm	ı			
	20th surface						:	3rd surface					
	k = 0.000 A4 = 7.96105 21th surface	5e-11				— 5 —		k = 1.920 A4 = -6.92724e 6th surface	:-05				
	k = 0.000 A4 = 1.79636 22th surface	бе-10				10		k = 0.000 A4 = 1.06996e– 14th surface	04				
	k = 0.000 A4 = 2.08521 23th surface	le-10				_		k = -0.579 A4 = -5.87534e 15th surface	:-05				
	k = 0.000 $A4 = -7.3601$	17e-04, A	6 = 1.851286	÷-08		— 15 —		k = 0.000 A4 = -1.97727e 16th surface	:-04				
		Various	data				1	k = 0.000					
	NA.			0.40	1	20		A4 = -3.03525e	-04				
	Magnification			-1.60			-	17th surface					
	Focal length mage height (mm			5.39 4.92				k = 0.000	00				
	mage neight (mm b (mm) (in air)	1)		1.71				A4 = 2.27302e- 18th surface	08				
I	ens total length (mm) (in a	ir)	50.89)	_ 25		k = 0.000 A4 = 1.91296e– 19th surface	05				
		Exampl	le 29			30]	k = 0.000 A4 = 1.02712e- 20th surface	04				
		I Init w				_	- 1	k = 0.000 A4 = 9.87048e-	11				
		Unit m Surface				_		A4 = 9.870486- 21th surface	11				
urface no.	r	d	nd	vd	θgf	35		k = 0.000 A4 = 9.22769e-	11				
						_							
[* <u>2</u> *	25.723 149.616	3.03 0.54	1.84666	23.77	0.620		-	k = 0.000					
*	19.523	3.74	1.49700	81.61	0.538			A4 = 9.06991e-	11				
ļ ;	156.580 20.438	0.10 3.50	1.49700	81.61	0.538	40	<u>:</u>	23th surface					
, 5*	-18.183	0.15	1.49700	61.01	0.556		j	k = 0.000					
,	-28.405	3.65	1.61800	63.33	0.544			A4 = -8.67255e	-04, A6 =	= 8.57757e -0	7		
3	-10.074 -29.736	0.70 0.03	1.72047	34.71	0.583	-		7	⁄arious da	ta			
(Stop)	∞	0.98				45 -			arrous da	···			
2	-37.887 10.973	0.70 3.19	1.90366 1.61800	31.32 63.33	0.595 0.544	45	NA	10 - 11			0.31		
3	-29.734	5.20	1.01600	05.55	0.5			iification length			-1.56 5.41		
1*	11.850	4.46	1.49700	81.61	0.538		Image	e height (mm)			4.92		
5* 5*	32.907 -43.174	6.37 0.70	1.49700	81.61	0.538			m) (in air) total length (mn	n) (in air)		1.70 50.87		
7*	-583.895	1.39				50 -	Lells	com rengtii (IIII)) (m an)		50.07		
}*)*	16.200 16.507	4.17	1.58364	30.30	0.599								
)*)*	-16.507 -13.189	2.96 0.70	1.49700	81.61	0.538			Ex	kample	30			
L*	14.167	2.41						157	ampie	20			
2* 3*	-9.282 18.028	0.50 1.20	1.53368	55.90	0.563								
1	∞ ∞	0.30	1.51640	65.06	0.535	55 _							
S	8	0.31							Unit mm				
nage plane			<u> </u>					S	urface da	ta			
		herical su	rface data			– 60	Surface no.	r	d	nd	νd	θgf	
	1st surface					_ " -	1*	19.930	3.24	1.84666	23.77	0.620	
	k = 0.000						2*	61.126	0.64				
	A4 = 4.82416 2nd surface	e=05					3* 4	20.022 64.679	2.36 0.10	1.49700	81.61	0.538	
	-						5	14.877	3.79	1.49700	81.61	0.538	
	k = 0.000	70.05				65	6 *	-20.728	0.44	1 41 900	62.22	0.544	
	A4 = 4.12737	7e-05					7	-22.514	2.78	1.61800	63.33		

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	-(continue	eu					-0	ontinue	zu .		
		Unit mm	ı						Unit mm			
8	-8.591	0.70	1.72047	34.71	0.583	- 5	,	mm) (in air)			1.70	
9 10(Store)	-28.840	0.09				,	Ler	is total length (mn	n) (in air)		50.72	
10(Stop) 11	∞ -75.968	0.69 0.70	1.90366	31.32	0.595	_						
12	10.025	3.17	1.61800	63.33	0.544							
13	-47.134	7.43	1.01800	05.55	0.544							
14*	11.048	4.18	1.49700	81.61	0.538			Ex	ample i	3.1		
15*	29.122	8.18	1.13700	01.01	0.000	10		LA	ampic.	<i>J</i> 1		
16*	16.083	3.74	1.58364	30.30	0.599							
17*	-23.253	3.00										
18*	-11.275	0.70	1.49700	81.61	0.538	_						
19*	22.496	2.40							Unit mm			
20*	-8.030	0.70	1.53368	55.90	0.563	-		_				
21*	19.993	1.20				15 _		S	urface dat	а		
22	∞	0.30	1.51640	65.06	0.535		Surface no.	. r	d	nd	νd	θgi
23 Imaga plan	∞ ne ∞	0.31				_	Surface no.	. 1	u	nu	vu	og.
Image plan	ie &						1*	22.255	1.40	1.84666	23.77	0.62
	Acaba	rical surfa	ace data			_	2*	49.454	0.10	1.07000	<i>⊑J.</i> 11	0.02
	Asplie	. rear ourla	or uata			-	3*	15.934	1.56	1.49700	81.61	0.53
	1st surface					20	4	49.074	0.10			
						_	5	8.678	2.60	1.49700	81.61	0.53
	k = 0.000						6*	24.865	0.10			
	A4 = 5.96209e -	05					7	16.464	2.59	1.62041	60.29	0.54
	2nd surface					_	8	-16.180	0.71	1.72047	34.71	0.58
						 25	9	20.086	0.50			
	k = 0.000					23	10(Stop)	oo 16335	-0.14	1.00266	21.22	0.50
	A4 = 4.52358e-	-05					11	16.335	0.77	1.90366	31.32	0.59
	3rd surface					_	12 13	4.955	2.54 0.10	1.62041	60.29	0.54
	1 2 404						13 14*	13.367 8.375	3.54	1.49700	81.61	0.53
	k = 3.494	0.4					15*	12.841	5.26	1.77/00	01.01	0.53
	A4 = -1.04703e	-04				30	16*	18.465	1.08	1.49700	81.61	0.53
	6th surface					_	17*	20.987	1.60			
	1- 0.000						18*	17.258	3.54	1.58364	30.30	0.59
	k = 0.000	0.4					19*	-13.619	2.16			
	A4 = 1.16629e-	·U4					20*	-7.110	0.80	1.49700	81.61	0.53
	14th surface					_	21*	6.864	4.38			
	k = -0.579					35	22*	38.244	1.35	1.53368	55.90	0.56
	K = -0.579 A4 = -1.22009e	-05					23*	40.675	1.79			0.5-
	A4 = -1.220096 15th surface	, 00					24 25	8	0.38 0.31	1.51640	65.06	0.53
	15th Sallace					_	Image plan		0.31			
	k = 0.000					_	mage plan					
	A4 = 9.35253e -	-06				• • •		Aspher	ical surfa	ce data		
	16th surface	- 0				40		. Lepiter				
						_		1st surface				
	k = 0.000											
	A4 = -4.21205e	-05						k = 0.000				
	17th surface							$A4 = 9.39832e^{-1}$	05			
						- 45		2nd surface				
	k = 0.000					43		1- 0.000				
	A4 = 3.29945e -	05						k = 0.000 $A4 = 2.63124e^{-6}$	05			
	18th surface							3rd surface	U.J.			
						_		212 2411400				
	k = 0.000							k = 1.034				
	A4 = 2.14586e -	04				50		A4 = -8.38701e	-05			
	19h surface					_		6th surface				
						_		_				
	k = 0.000							k = 0.000				
	A4 = 2.96805e -	04						A4 = 2.34844e-	04			
	20th surface					_		14th surface				
				_		55		lr = 0.570				
	k = 0.000							k = -0.579 A4 = -1.61090e	_04			
	A4 = 8.17176e-	.05						15th surface	J-1			
	21th surface					_		25 di Sullace				
	1- 0.000							k = 0.000				
	k = 0.000	04:5	7.0000	· 7				$A4 = 9.62591e^{-1}$	05			
	A4 = -6.90519e	:-U4, A6 =	= /.86063e=0) /		60		16th surface				
	7	Various da	ita			-						
		various da	на			_		k = 0.000	0.4			
NA				0.31		_		A4 = -2.20378e	-04			
	gnification			-1.55				17th surface				
	cal length			5.52		65		k = 0.000				
	age height (mm)			4.92				$A4 = 1.44465e^{-1}$	04			
ши	-5- neight (IIIII)			7.72				1	· ·			

Aspherical surface data

1st surface

k = 0.000 A4 = 6.50944e-05

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	-c	ontinue	ed			_		-	continue	ed		
		Unit mm				_			Unit mm			
18	th surface					- - 5		2nd surface				
A	= 0.000 4 = 5.22295e–0 th surface	05				_		k = 0.000 A4 = 5.45929e- 3rd surface	-05			
A	= 0.000 4 = -1.67837e- th surface	-04				10		k = 0.635 A4 = -3.35884 6th surface	e-05			
A	= 0.000 4 = 2.06606e-(th surface	04				_		k = 0.000 A4 = 1.78338e- 14th surface	-04			
A	= 0.000 4 = -1.79135e- th surface	-04				15		k = -0.579 A4 = -1.63080 15th surface	e-07			
A	= 0.000 4 = -1.13764e- th surface	-04				20		k = 0.000 A4 = 7.02281e- 16th surface	-08			
	= 0.000 4 = -6.19905e-	-04, A6 =	-1.16506e-	-05		_		k = 0.000 A4 = -2.61423 17th surface	e-04			
	V	arious dat	a			_ 25		k = 0.000				
NA Magnif	ication			0.20 -2.00				A4 = -6.188296 18th surface	e-04			
fb (mm	ength height (mm)) (in air) tal length (mm	n) (in air)		6.48 4.92 2.35 38.99		30		k = 0.000 A4 = 4.05381e- 19th surface	-10			
						-		k = 0.000 A4 = -6.67366 20th surface	e-10			
	Ex	ample 3	32					20 th bullage				
	Ex	ample 3	32			35		k = 0.000 A4 = 3.21970e-	-10			
		ample 3	32			35		k = 0.000 A4 = 3.21970e- 21th surface	-10			
						- - -		k = 0.000 A4 = 3.21970e-		-7.28026e-0	06	
Surface no.		Unit mm		vd	θgf	35 - - - 40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e-			06	
Surface no. 1* 2* 3* 4	St	Unit mm urface data	a	vd 23.77 81.61	θgf 0.620 0.538	- - -		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length	-04, A6 = -		0.23 -2.00 10.51	
1* 2* 3* 4 5	r 18.031 33.383 14.122 112.900 10.797	Unit mm urface data d 1.98 0.30 2.63 0.10 2.81	nd 1.84666	23.77	0.620	- - -		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air)	-04, A6 = -		0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64	nd 1.84666 1.49700 1.49700 1.61800	23.77 81.61 81.61 63.33	0.620 0.538 0.538 0.544	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm)	-04, A6 = -		0.23 -2.00 10.51 4.92	
1* 2* 3* 4 5	r 18.031 33.383 14.122 112.900 10.797 43.886	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22	nd 1.84666 1.49700 1.49700	23.77 81.61 81.61	0.620 0.538 0.538	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air)	-04, A6 = -		0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8 9 10(Stop)	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33	nd 1.84666 1.49700 1.49700 1.61800 1.72047	23.77 81.61 81.61 63.33 34.71	0.620 0.538 0.538 0.544 0.583	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m	-04, A6 = -	ta	0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49	nd 1.84666 1.49700 1.49700 1.61800	23.77 81.61 81.61 63.33	0.620 0.538 0.538 0.544	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m	-04, A6 = - Various dat m) (in air)	ta	0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 \$\infty\$ 21.319 5.225 10.578	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800	23.77 81.61 81.61 63.33 34.71 31.32 63.33	0.620 0.538 0.538 0.544 0.583 0.595 0.544	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m	-04, A6 = - Various dat m) (in air)	ta	0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14*	r 18.031 33.383 14.122 112.900 10.797 43.886 -13.093 24.412 21.319 5.225 10.578 7.000	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366	23.77 81.61 81.61 63.33 34.71	0.620 0.538 0.538 0.544 0.583	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m	-04, A6 = - Various dat m) (in air)	ta	0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16*	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 21.319 5.225 10.578 7.000 8.979 11.132	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27 9.72 4.18	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800	23.77 81.61 81.61 63.33 34.71 31.32 63.33	0.620 0.538 0.538 0.544 0.583 0.595 0.544	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fo (mm) (in air) Lens total length (m	-04, A6 = - Various daf m) (in air) xample :	33	0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17*	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 ∞ 21.319 5.225 10.578 7.000 8.979 11.132 -33.189	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27 9.72 4.18 2.46	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800 1.49700 1.58364	23.77 81.61 81.61 63.33 34.71 31.32 63.33 81.61 30.30	0.620 0.538 0.538 0.544 0.583 0.595 0.544 0.538	40		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fo (mm) (in air) Lens total length (m	-04, A6 = - Various dat m) (in air)	33	0.23 -2.00 10.51 4.92 2.83	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18* 19*	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 21.319 5.225 10.578 7.000 8.979 11.132	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27 9.72 4.18	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800 1.49700	23.77 81.61 81.61 63.33 34.71 31.32 63.33 81.61	0.620 0.538 0.538 0.544 0.583 0.595 0.544 0.538	40 45 50		k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fo (mm) (in air) Lens total length (m	-04, A6 = - Various daf m) (in air) xample :	33	0.23 -2.00 10.51 4.92 2.83	θgí
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18* 19* 20*	18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 21.319 5.225 10.578 7.000 8.979 11.132 -33.189 -6.616 19.087 -10.000	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27 9.72 4.18 2.46 0.73 5.41 1.47	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800 1.49700 1.58364	23.77 81.61 81.61 63.33 34.71 31.32 63.33 81.61 30.30	0.620 0.538 0.538 0.544 0.583 0.595 0.544 0.538	40 45 50	Surface no.	k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m	m) (in air) xample 2 Unit mm Surface dat	333	0.23 -2.00 10.51 4.92 2.83 44.85	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18* 19* 20* 21*	r 18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 21.319 5.225 10.578 7.000 8.979 11.132 -33.189 -6.616 19.087 -10.000 -8.861	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27 4.18 2.46 0.73 5.41 1.47 2.27	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800 1.49700 1.58364 1.49700 1.53368	23.77 81.61 81.61 63.33 34.71 31.32 63.33 81.61 30.30 81.61 55.90	0.620 0.538 0.538 0.544 0.583 0.595 0.544 0.538 0.599 0.538	40 45 50	Surface no.	k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m E	m) (in air) xample : Unit mm Surface dat d 2.85	333	0.23 -2.00 10.51 4.92 2.83 44.85	
1* 2* 3* 4 5 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18* 19* 20*	18.031 33.383 14.122 112.900 10.797 43.886 23.680 -13.093 24.412 21.319 5.225 10.578 7.000 8.979 11.132 -33.189 -6.616 19.087 -10.000	Unit mm 1.98 0.30 2.63 0.10 2.81 0.22 2.64 0.70 0.49 -0.33 0.72 2.41 0.10 3.27 9.72 4.18 2.46 0.73 5.41 1.47	nd 1.84666 1.49700 1.49700 1.61800 1.72047 1.90366 1.61800 1.49700 1.58364 1.49700	23.77 81.61 81.61 63.33 34.71 31.32 63.33 81.61 30.30 81.61	0.620 0.538 0.538 0.544 0.583 0.595 0.544 0.538 0.599	40 45 50	Surface no.	k = 0.000 A4 = 3.21970e- 21th surface k = 0.000 A4 = 2.90162e- NA Magnification Focal length Image height (mm) fb (mm) (in air) Lens total length (m	m) (in air) xample 2 Unit mm Surface dat	333	0.23 -2.00 10.51 4.92 2.83 44.85	0.620 0.574

0.563	Surface no.	r	d	nd	vd
0.563	1*	20.173	2.85	1.84666	23.77
0.535	2*	44.670	0.10		
60	3	22.987	0.70	1.65412	39.68
60	4	13.553	0.10		
	5*	11.056	5.41	1.49700	81.61
	6	-117.884	0.10		
	7	15.197	3.48	1.49700	81.61
	8*	-137.586	0.10		
	9	40.695	3.13	1.61800	63.33
65	10	-15.237	0.70	1.72047	34.71
	11	13.540	0.95		

0.538

0.544 0.583

166 Example 34

		Unit mm				-						
12(Stop) 13	∞ 21.538	-0.41 0.70	1.90366	31.32	0.595	5		Un	it mm			
13 14	6.309	2.36	1.61800	63.33	0.544			Surf	ace data			
15	11.008	0.10	1 40700	01.71	0.539		-	Sun	ar uata			
16* 17*	6.948 -55.578	3.38 5.87	1.49700	81.61	0.538		Surface no.	r	d	nd	νd	θgf
18*	-6.796	0.70	1.49700	81.61	0.538		1	30.333	3.43	1.84666	23.77	0.620
19*	18.459	2.11	1.50264	20.20	0.500	10	2*	-17.121	0.96	1.04000	23.77	0.020
20* 21*	7.634 -13.003	3.91 1.75	1.58364	30.30	0.599		3*	-13.803	0.88	1.58364	30.30	0.599
22*	-6.810	0.70	1.49700	81.61	0.538		4* 5*	13.612 11.200	0.11 3.75	1.49700	81.61	0.538
23*	24.381	4.54	1.51.640		0.525		6	-27.595	0.10	1.49700	61.01	0.556
24 25	∞ ∞	0.38 0.30	1.51640	65.06	0.535	1.5	7	15.356	3.57	1.49700	81.61	0.538
Image plane	∞	0.50				15	8* 9	-16.003 17.504	0.10 2.87	1.61800	63.33	0.544
						-	10	-11.810	0.70	1.72047	34.71	0.583
	Aspher	ical surfa	ce data			_	11	8.524	0.97			
	1st surface					_	12 (Stop)	œ	0.56	4 50045	24.74	
						- 20	13 14	-53.831 6.850	0.70 2.02	1.72047 1.61800	34.71 63.33	0.583 0.544
	k = 0.000					20	15	23.795	2.48	1.01600	05.55	0.544
	A4 = -5.73554e $2nd surface$	-06					16*	16.577	4.50	1.49700	81.61	0.538
	2lid surface					_	17*	-46.561	1.38	1 40700	01.61	0.530
	k = 0.000						18* 19*	20.918 198.692	2.44 2.30	1.49700	81.61	0.538
	A4 = -9.15135e	-06				25		15.525	2.93	1.63490	23.88	0.630
	5th surface						21*	-50.829	5.23			
	k = -0.393						22* 23*	-9.522 17.577	0.71 1.58	1.53368	55.90	0.563
	A4 = -2.44007e	-05					24*	-21.349	0.92	1.53368	55.90	0.563
	8th surface					_	25*	27.363	0.66			
	k = 0.000					30	26	∞	0.38	1.51640	65.06	0.535
	A4 = 6.95514e-0	05					27 Image plane	8	0.30			
	k = -0.579					_		Aspherica	l surface da	ta		
	A4 = -2.22085e- 17th surface	-04				2.5	<u> </u>	2nd surfa				
	17th surface					_ 35		k = -3.17				
	k = 0.000							3rd surfac k = 0.000				
	A4 = -4.21651e 18th surface	-04						A4 = 7.36				
	18th surface					_		4th surfac				
	k = 0.000					40		k = 0.000	21732e-04			
	A4 = -3.61868e	-04						5th surfac				
	19th surface					_		k = -0.07				
	k = 0.000							A4 = -1.8 8th surfac	81623e-04			
	A4 = -7.75281e	-04						k = -6.61				
	20th surface					_ 45		A4 = 3.49				
	k = 0.000							16th surfa				
	A4 = -6.02773e	_∩4						k = -0.57 A4 = 1.35				
	21th surface	· .						17th surfa				
						_		k = 0.000				
	k = 0.000					50		A4 = 2.51 $18th surfs$				
	A4 = -6.83570e $22th surface$	-05						k = 0.000				
	22111 3111111111					_		A4 = 2.91				
	k = 0.000							19th surfa k = 0.000				
	A4 = 1.18563e - 0)9						A4 = 6.43				
	23th surface					_ 55		20th surfa	ace			
	k = 0.000							k = -1.06				
	A4 = -1.14221e	-09, A 6 =	-1.28369e-	-05				A4 = 1.69 21th surfa				
		•				-		k = 0.000				
	V:	arious dat	.a			- 60		A4 = 2.58 $22th surfa$				
N.	A			0.23				k = 0.000				
	agnification			-1.33					19918e-04			
	ocal length			10.24				23th surfa				
	nage height (mm) (mm) (in air)			4.92 5.09				k = 0.000 $A4 = -14$	19907e-04			
	(mm) (m air) ens total length (mm	ı) (in air)		43.88		65		A4 = -1.2 24th surfa				
		., ()										

Customer		-0	continue	ed						-continue	ed			
Name			Unit mm				-			Unit mm				
Part		A4 = 1	L.57977e-	-04			- 5		16	th surface				
Magnification		k = 0.0	000	e-04					A4	l = 8.24143e-	-06			
Magnification -1-33		V	arious da	ta			10		A ²	l = 2.95157e-	-05			
Example 35	Magnification Focal length Image height (mm fb (mm) (in air)	,			-1.33 6.71 4.92 1.21		15		k = A4 19 k = A4	= -4.329 I = 1.98827e-th surface = 0.000 I = 1.82474e-				
Surface no. Surface data Surface data Surface no.		Unit mm Surface data							k = A4	= 0.000 l = -5.85060e	e-05			
Surface no.			T.T 14				_		A4	l = 7.89211e-	-12			
Surface no.							- 25		_					
1	Surface no.				vd	θgf	- ~		A-	l = −1.93685¢	e-04			
1,4,498 0,11 5,498 0,11 5,499 1,49700 81,61 0,538 6				1.84666	23.77	0.620	-		k =	= 0.000				
11.902	-			1.58364	30.30	0.599	30		A ²	l = -5.50486e	e-04			
8* -16,536 0,10 0,238 NA 0,238 0,244 0,244 0,	•								Various data					
8*	-			1.49700	81.61	0.538		NA 0						
10	8*	-16.536	0.10					N	/lagnification			-1.33		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $							35			a)				
13				1.72047	34.71	0.363				.1)				
14				1 72047	34 71	0.583		L	ens total length	(mm) (in air)		46.76		
1.5														
10* 12.506 4.84 1.49700 81.61 0.538 1.79 0.58 1.89 0.59 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75				1 10700	01.61	0.520	40							
18*				1.497/00	81.61	0.538				Evample	36			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.63490	23.88	0.630				Example	30			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$														
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.53368	55.90	0.563								
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.53368	55.90	0.563	45			Unit mm				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.51.640	65.06	0.535				C	4-			
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				1.51040	05.00	0.555				Surrace da	ıa			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Image plane						_					νd	θgf	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		Asphei	rical surfa	ce data			50 -				1.84666	23.77	0.620	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		2nd su	ırface				_	3*	-14.367	0.70	1.58364	30.30	0.599	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		k = -3	.154								1.49700	81.61	0.538	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$							_	6	-22.078	0.10				
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		1. 07	200				55				1.49700	81.61	0.538	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$				-05							1.61800	63.33	0.544	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$							_	10	-13.673	0.70			0.583	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		1 _e = 0.0	200	· <u> </u>		_								
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				e-04							1.72047	34.71	0.583	
							60 —	14	7.839	2.04			0.544	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		1 04					_				1.40700	01 (1	0.530	
8th surface 18* 14.851 2.87 1.63490 23.88 19* -125.046 5.08 k = -4.445 65 20* -7.502 0.70 1.53368 55.90				e=04							1.49/00	81.61	0.538	
				0.7							1.63490	23.88	0.630	
								19*	-125.046	5.08				
A4 = 2.87986e - 05 21* 12.654 2.99				05			65				1.53368	55.90	0.563	
A4 = 2.87986e-05 21* 12.654 2.99		A4 = 2	2.0/9800-	-03				21.	12.654	∠.99				

		169 -continue	ed						170 -continue	ed		
		Unit mm				-			Unit mm			
22 23 Image plane	& & &	0.38 0.30	1.51640	65.06	0.535	- 5	7 8* 9	18.037 -15.488 17.578	0.30	1.49700 1.61800	81.61 63.33	0.538 0.544
- mage plane		'1C	1			-	10	-11.708	3 0.71	1.72047	34.71	0.583
	Asph	erical surfa	ice data			_	11 12(Stop)	8.76∠ ∞	4 1.28 0.86			
	2nd s	surface				_ 10	13	-50.664		1.72047	34.71	0.583
		-2.632 surface				- 10	14 15 16*	6.843 22.209 18.515	3.20	1.61800 1.49700	63.33 81.61	0.544
						-	17*	-19.905	0.36			
	k = 0 A4 =).000 = 2.85023e-	-05				18* 19*	61.312 -138.576		1.49700	81.61	0.538
		urface				15	20*	16.819	3.04	1.63490	23.88	0.630
	k = 0	000					21* 22*	-44.496 -6.697		1.53368	55.90	0.563
		-1.67992	e-04				23*	12.737		1.55500	33.70	0.505
	5th s	urface				_	24	91.429		1.53368	55.90	0.563
	k = -	-0.266					25 26	100.508 ∞	0.51 0.38	1.51640	65.06	0.535
		-1.93461	e-04			20	27	∞	0.30	1.51010	03.00	0.000
	8th s	urface				_	Image plane	∞				
		-4.885 9.963126	06					As	spherical surfa	ice data		
		surface				- 25		21	nd surface			
	A4 =	-0.579 = 1.15323e- surface	-05						= -3.277 rd surface			
	k = 0 A4 =).000 = 8.61252e-	-05			30		A	= 0.000 4 = 8.48353e- th surface	-05		
	k = -	surface -1.042 -5.95706e-	-05			_		A	= 0.000 4 = -1.018986 th surface	e-04		
		surface				- ₃₅		k	= -0.286 4 = -1.38466	- 04		
	A4 =	8.80359e- surface	-05			_		81	th surface			
).000 = 4.18334e- surface	-04			40		A	= -5.555 4 = 4.80018e- 6th surface	-05		
	k = 0 A4 =).000 = -2.24974	e-04			_		A	= -0.579 .4 = 1.25353e- 7th surface	-04		
NA		Various da	ta	0.23		4 5		A	= 0.000 4 = 2.20448e- 8th surface	-04		
Focal Image Fb (m	ification length height (mm) m) (in air) total length (m	um) (in cir)		-1.33 8.73 4.92 3.55 47.77		50		A	= 0.000 .4 = 3.34293e- 9th surface	-04		
Lens		Example		47.77		-		A	= 0.000 4 = 1.43266e- 0th surface	-04		
		Manipie				55 -		A	= -4.552 4 = 2.56841e- 1th surface	-04		
		Unit mm						k	= 0.000			
		Surface da	ta			-		A	.4 = 2.84837e- 2th surface	-04		
Surface no.	r	d	nd	νd	θgf	60 -		k	= 0.000			
1 2*	35.018 -16.160	3.51 0.79	1.84666	23.77	0.620				.4 = 2.73060e- 3th surface	-04		
3*	-14.606	0.70	1.58364	30.30	0.599			_				
4* 5*	12.706 10.540	0.30 4.39	1.49700	81.61	0.538	65			= 0.000 4 = -9.166486	04		
6	-25.094	0.10	1.47/00	01.01	0.550	0.0		A	>.100400	V V T		

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-continued	

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	`	commuc	Ju					· ·	commu	. Ca		
		Unit mm				_		18th s	surface			
NA		Various dat	ta	0.23		_ 5			.000 2.23578e- surface	-04		
Foc Ima	gnification cal length age height (mm) (mm) (in air)			-1.33 8.25 4.92 1.06					.000 1.34637e- surface	-04		
Len	ns total length (mr			48.56		10			3.507 3.22843e- surface	-04		
	Ez	xample :	38			15			.000 3.61442e- surface	-04		
		Unit mm				_		k = 0.	.000			
	S	Surface dat	ta						–5.637826 surface	e-04		
urface no.	r	d	nd	νd	θgf	20		k = 0.	.000			
1 2*	49.656	3.69	1.84666	23.77	0.620	_		A4 =	-1.157286	e-03		
3*	-17.011 -16.943	0.30	1.58364	30.30	0.599			7	Various da	ta		
4* 5*	15.231 12.554	0.30 5.18	1.49700	81.61	0.538	25	N.				0.23	
6 7	-22.778 19.262	0.10 4.38	1.49700	81.61	0.538			agnification cal length			-1.33 9.31	
3* 9	-14.960 23.487	0.30 2.73	1.61800	63.33	0.544			nage height (mm) (mm) (in air)			4.92 3.49	
) [-17.685 9.522	0.70 1. 44	1.72047	34.71	0.583	30	Le	ens total length (mi	m) (in air)		53.44	
2(Stop)	∞ -38.910	0.85	1.72047	34.71	0.583	50						
1	6.507	2.02	1.61800	63.33	0.544					• 0		
5 5*	13.505 14.532	1.43 8.57	1.49700	81.61	0.538			E	xample	39		
7* 8*	57.509 13.489	0.41 4.45	1.49700	81.61	0.538	35						
)*)*	-401.830 15.589	1.74 3.51	1.63490	23.88	0.630				Unit mm			
1* 2*	-58.753 -7.832	4.86 1.58	1.53368	55.90	0.563			5	Surface da	ta		
3* 4	15.936 ∞	2.94 0.38	1.51640	65.06	0.535	40	Surface no.	r	d	nd	νd	θgf
i nage plane	& &	0.30					1*	15,101	3.29	1.49700	81.61	0.538
ge prane		rical surfac	ce data			-	2* 3	-1411.511 -675.554	0.81 0.86	1.50220	54.74	0.551
	2nd st		ce data			- 45	4 5*	13.373	1.32 5.03			0.531
						- "	6	14.021 -18.164	0.10	1.49700	81.61	
	k = -2 3rd su						7 8*	14.881 -54.750	3.21 0.32	1.49700	81.61	0.538
		-1.47660e	e-05			50	9 10 11	50.000 -18.151 -3000.000	3.52 1.71 0.50	1.61800 1.72047	63.33 34.71	0.544 0.583
	4th su					_	12(Stop) 13	∞ 47.485	0.37 4.43	1.75500	52.32	0.547
		-1.00180e	e-04				14 15	-30.000 6.109	1.93 3.62	1.71775	32.36	0.593
	5th su	rface				- 55	16* 17*	-7.419 -8.241	4.50 0.90	1.49700	81.61	0.538
	k = -0 A4 = -).298 –1.23946e	e-04			55	18* 19*	12.630 -59.865	4.46 3.19	1.80610	40.40	0.570
	8th su					_	20* 21*	-14.507 19.347	1.72 1.54	1.60614	32.96	0.598
		1.494 1.28557e– urface	-05			60	22 23 Image plane	19.347	0.38 0.31	1.51640	65.06	0.535
	I our b					_						
	k = -0							Asphe	rical surfa	ce data		
	k = -0 $A4 = 0$).579 1.96708e- urface	-04					Asphe 1st surface	rical surfa	ce data		

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	-0	continue	ed					-0	continue	ed		
		Unit mm							Unit mm			
2n	ıd surface						20*	20.278	1.43			
A	= 0.000 4 = 1.15283e-	-04				- 5	21 22 Image plane	& & &	0.38 0.31	1.51640	65.06	0.53
	h surface							Asphe	rical surfa	ce data		
A	= -0.990 4 = 1.66321e- h surface	-05				10	1st s	surface				
k :	= 0.000 4 = 1.25514e-	-04				_	A4 :	0.000 = 7.72147e-06 surface	, A6 = -1	.56655e-07		
k :	th surface = -0.579					15	A4 :	0.000 = 4.95212e-06				
	4 = −1.39447e ′th surface	÷-05					3rd	surface				
A	= 0.000 4 = 6.26727e-	-05				20	A4 :	0.000 = 7.51990e-06 surface	i			
k :	sth surface = 0.000 4 = -5.34476e	÷-05				-	A4 :	-0.280 = -4.12102e-0 surface)5			
k :	oth surface = 0.000 4 = -7.96647e	>_05				25	A4 :	0.000 = 9.26104e-05 1 surface				
20	4 = -7.966476 th surface = 0.000					-	<u>k</u> =	-0.579 = -1.80982e-0	15			
21	4 = 6.62595e- th surface	-05				30	k =	0.000				
	= 0.000 4 = -6.63922e			06		_	<u>17th</u>	= 6.97386e-05 n surface				
NA NA		Various da	ta	0.23		- 35	A4 :	0.000 = -8.07041e-0 n surface	15			
fb (mm	ength height (mm) ı) (in air)			-1.30 11.64 4.92 2.10			A4 :	0.000 = -1.42087e-0 1 surface)4			
Lens to	otal length (mr	n) (in air)		47.88		- ⁴⁰	A4 :	0.000 = 1.27864e-04 1 surface				
	Ez	xample	40			45	k =	0.000 = -1.23475e-0	94, A6 = -	7.64122e-06	5	
						45 -		V	/arious da	a		
		Unit mm					NA				0.23	
	S	Surface dat	ta			-	Magni Focal	fication length			-1.30 11.19	
Surface no.	r	d	nd	vd	θgf	5 0	Image	height(mm)			4.92 1.99	
1* 2*	13.980 -20.000	5.56 0.90	1.49700 1.51633	81.61 64.06	0.538 0.533	_		otal length(mm	ı) (in air)		47.51	
3* 4*	13.407 13.448	1.32 4.59	1.49700	81.61	0.538			_	٠			
5 6	-23.931 20.404	0.10 3.02	1.49700	81.61	0.538	55		Ex	kample 4	41		
7* 8	-54.118 15.790	0.30 4.48	1.61800	63.33	0.544							
9 10	-19.586 16.357	0.70 0.91	1.72047	34.71	0.583	_			Unit mm			
11(Stop)	∞ 14.986	0.94 4.50	1.75500	52.32	0.547	60			urface dat	·a		
	-30.000	1.15	1.75500	32.32 35.70	0.589	_				а		
12 13		3.03			0.539		Surface no.	r	d	nd	vd	θgf
12 13 14	5.558		1.40700	81 61								
12 13 14 15* 16*	5.558 -7.759 -9.446	4.50 0.30	1.49700	81.61	0.538	_	1	25.769	1.00	1.78800	47.37	0.55
12 13 14 15*	5.558 -7.759	4.50	1.49700 1.80610	81.61 40.40	0.538	65	1 2 3	25.769 18.855 -40.476	1.00 2.85 5.37	1.78800 1.84666	47.37 23.78	0.55

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						_						
		Unit mm	1			_						
5*	11.476	0.10				5			Unit mm			
6* 7*	8.066 -8.996	3.75 0.10	1.49700	81.61	0.538	-		S	urface da	ta		
8	24.048	2.60	1.61800	63.33	0.544	_	G C			ı	1	
9	-8.000	1.00	1.72047	34.71	0.583	_	Surface no.	r	d	nd	νd	θд
10 11(Stop)	26.872 ∞	1.85 0.30				10	1	40.476	1.93	1.84666	23.78	0.62
11(Stop)	9.076	0.60	1.90366	31.32	0.595		2 3	-18.855 -25.769	1.00 5.63	1.78800	47.37	0.5:
13	5.849	1.82	1.53996	59.46	0.544		4*	-12.272	1.63	1.58366	30.23	0.5
14	16.303	1.19					5*	12.511	0.10	1 40700	01.61	0.5
15 16	10.078 27.029	2.13 0.10	1.49700	81.61	0.538		6* 7*	8.053 -9.092	3.59 0.10	1.49700	81.61	0.5
17*	14.378	3.00	1.63491	23.81	0.624	15	8	36.029	2.41	1.61800	63.33	0.5
18*	-11.061	0.10	1100 171	20.01	0.02		9 10	-8.000 127.453	1.85 0.79	1.72047	34.71	0.5
19	30.935	1.06	1.49700	81.61	0.538		11(Stop)	127.433 ∞	0.79			
20	5.275	2.65	4.77400	26.12	0.644		12	11.461	0.60	1.90366	31.32	0.5
21 22	-8.961	3.00	1.75299	26.43	0.613	20	13 14	5.817 12.210	1.60 0.10	1.53996	59.46	0.5
23*	-10.149 -7.320	5.48 0.60	1.63491	23.81	0.624	20	15	8.567	1.27	1.48749	70.23	0.5
24*	17.259	1.08	2.00 171	25.01			16	13.023	0.57			
25	∞	0.38	1.51641	65.06	0.535		17 18	12.975 21.711	1.75 0.10	1.49700	81.61	0.5
26	∞	0.29					19*	13.032	3.00	1.63491	23.81	0.6
Image plane	∞					25	20*	-10.432	0.10			
	Ambo	rical surfa	ace data			-	21 22	32.856 5.469	1.80 3.30	1.49700	81.61	0.5
	Asplic	iicai suiia	ice uata			_	23	-8.726	3.00	1.84666	23.78	0.6
4th surface							24	-9.698	4.14			
						-	25* 26*	-7.320 17.259	0.60 1.08	1.63491	23.81	0.6
k = 0.000						30	26* 27	17.259 ∞	0.38	1.51641	65.06	0.5
A4 = -1.764296	e-04, A6 = 6.	30527e-0	07				28	œ	0.30	40 14		0.0
5th surface							Image plane	∞				
k = 0.000						_		Aspher	rical surfa	ce data		
1.4 2.22457								2 topiici	rear barra			
	e-04, A6 = -6	5.86686e-	-07			35	4th surface	7 кариел				
	e-04, A6 = -0	5.86686e-	-07			35	4th surface	2 isplies				
6th surface	e-04, A6 = -0	6.86686e-	-07			35	k = 0.000					
$\frac{6\text{th surface}}{k = -1.081}$ $A4 = -2.892786$						35	k = 0.000 $A4 = -2.20622$					
6th surface k = -1.081						_	k = 0.000 $A4 = -2.20622$ 5 th surface					
$\frac{6\text{th surface}}{k = -1.081}$ $A4 = -2.892786$ $\frac{7\text{th surface}}{2}$						35 - 40	k = 0.000 A4 = -2.20622 5th surface k = 0.000	ee-04, A6 = 1.	84877e-(06		
$\frac{6\text{th surface}}{k = -1.081}$ $A4 = -2.892786$ $\frac{7\text{th surface}}{2}$	e-04, A6 = 1.	34631e-(06			_	k = 0.000 $A4 = -2.20622$ 5 th surface	ee-04, A6 = 1.	84877e-(06		
6th surface k = -1.081 A4 = -2.89278 7th surface k = -0.300	e-04, A6 = 1.	34631e-(06			_	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39829 6th surface	ee-04, A6 = 1.	84877e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface	e-04, A6 = 1.	34631e-(06			_	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082	ee-04, A6 = 1.	84877e-(41106e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000	e-04, A6 = 1. -05, A6 = 1.4	34631e-(9990e-06	5	25570-	27	_	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39829 6th surface	ee-04, A6 = 1.	84877e-(41106e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e- 17th surface k = 0.000 A4 = -2.679156	e-04, A6 = 1. -05, A6 = 1.4	34631e-(9990e-06	5	.25579e-(07	40	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface	ee-04, A6 = 1.	84877e-(41106e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000	e-04, A6 = 1. -05, A6 = 1.4	34631e-(9990e-06	5	.25579e-(07	40	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170	ee-04, A6 = 1.	84877e-(41106e-(15880e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425c-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(9990e-06 3.04912e-	06 6 -06, A8 = -1			40	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface	ee-04, A6 = 1.	84877e-(41106e-(15880e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.594256- 17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.858026-	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(9990e-06 3.04912e-	06 6 -06, A8 = -1			40	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface	ee-04, A6 = 1.	84877e-(41106e-(15880e-(06		
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425c-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(9990e-06 3.04912e-	06 6 -06, A8 = -1			40	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000	ee-04, A6 = 1.	84877e-(41106e-(15880e-(4380e-0(06	.80800e-f	800
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425c- 17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802c- 23th surface	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(9990e-06 3.04912e-	06 6 -06, A8 = -1			45	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface	ee-04, A6 = 1.	84877e-(41106e-(15880e-(4380e-0(06	.80800e-C	208
6th surface k = -1.081 A4 = -2.8927867 7th surface k = -0.300 A4 = 4.59425c-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802c-23th surface k = 0.000	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(06 5 -06, A8 = -1 06, A8 = -2.9	98874e-08		45	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000 A4 = -1.93247 20th surface	ee-04, A6 = 1.	84877e-(41106e-(15880e-(4380e-0(06	.80800e-C	808
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425c- 17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802c- 23th surface	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(06 5 -06, A8 = -1 06, A8 = -2.9	98874e-08		45	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247	e-04, A6 = 1. e-04, A6 = 1. e-04, A6 = 2. e-05, A6 = 1.7	84877e-(41106e-(15880e-(4380e-06	06 06 06 5 -06, A8 = -5		208
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-486	e-04, A6 = 1.4 -05, A6 = 1.4 e-04, A6 = -:	34631e-(06 5 -06, A8 = -1 06, A8 = -2.9	98874e-08		- 40 - 45 - 50	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000	e-04, A6 = 1. e-04, A6 = 1. e-04, A6 = 2. e-05, A6 = 1.7	84877e-(41106e-(15880e-(4380e-06	06 06 06 5 -06, A8 = -5		8(3
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-24th surface k = 0.000	e-04, A6 = 1.4 e-04, A6 = -1.4 e-04, A6 = -2.4 e-04, A6 = -8.4 e-04, A6 = -1.4	34631e-(9990e-06 3.04912e- 69760e-(13249e-(06 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	98874e-08	8	45	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.924316 25th surface	e-04, A6 = 1. e-04, A6 = 1. e-04, A6 = 2. e-05, A6 = 1.7	84877e-(41106e-(15880e-(4380e-06	06 06 06 5 -06, A8 = -5		8(3)
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-24th surface	e-04, A6 = 1.4 e-04, A6 = -1.4 e-04, A6 = -2.4 e-04, A6 = -8.4 e-04, A6 = -1.4	34631e-(9990e-06 3.04912e- 69760e-(13249e-(06 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	98874e-08	8	- 40 - 45 - 50	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.924316	de-04, A6 = 1. de-04, A6 = 1. de-04, A6 = 2. de-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-0(2.53963e-(06 06 06 -06, A8 = -5	007e-08	88
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-24th surface k = 0.000	e-04, A6 = 1.4 e-04, A6 = -2 -04, A6 = -8 -04, A6 = -1 e-04, A6 = -1	34631e-(9990e-06 3.04912e- 69760e-(13249e-(53368e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91 05, A8 = -3.8	98874e-08	8	- 40 - 45 - 50	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.92431e 25th surface k = 0.000	de-04, A6 = 1. de-04, A6 = 1. de-04, A6 = 2. de-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-0(2.53963e-(06 06 06 -06, A8 = -5	007e-08	8(8
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-24th surface k = 0.000	e-04, A6 = 1.4 e-04, A6 = -2 -04, A6 = -8 -04, A6 = -1 e-04, A6 = -1	34631e-(9990e-06 3.04912e- 69760e-(13249e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91 05, A8 = -3.8	98874e-08	8	- 40 - 45 - 50	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.924316 25th surface k = 0.000 A4 = 8.845246 26th surface	de-04, A6 = 1. de-04, A6 = 1. de-04, A6 = 2. de-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-0(2.53963e-(06 06 06 -06, A8 = -5	007e-08	808
6th surface k = -1.081 A4 = -2.8927867th surface k = -0.300 A4 = 4.59425c-17th surface k = 0.000 A4 = -2.67915618th surface k = 0.000 A4 = 3.85802c-23th surface k = 0.000 A4 = 8.84524c-24th surface k = 0.000 A4 = -6.213606	e-04, A6 = 1.4 e-04, A6 = -2 -04, A6 = -8 -04, A6 = -1 e-04, A6 = -1	34631e-(9990e-06 3.04912e- 69760e-(13249e-(53368e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	08874e-08	8	- 40 - 45 - 50	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.924316 25th surface k = 0.000 A4 = 8.845246	2e-04, A6 = 1. 2e-04, A6 = 1. 2e-04, A6 = 2. 2e-04, A6 = 1.7 2e-04, A6 = -6. 2e-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-06 2.53963e-(94103e-(13249e-(06 06 06 -06, A8 = -5 06, A8 = 2.82	2007e-08 153e-07	
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-24th surface k = 0.000	e-04, A6 = 1.4 e-04, A6 = -04, A6 = -04, A6 = -1. e-04, A6 = -1.	34631e-(9990e-06 3.04912e- 69760e-(13249e-(53368e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	98874e-08	8	- 40 - 45 - 50 - 55	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.92431e 25th surface k = 0.000 A4 = 8.84524e 26th surface k = 0.000	2e-04, A6 = 1. 2e-04, A6 = 1. 2e-04, A6 = 2. 2e-04, A6 = -1. 2e-04, A6 = -1. 2e-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-06 2.53963e-(13249e-(53368e-(06 06 06 5 -06, A8 = -5 06, A8 = 2.82 05, A8 = 3.91	2007e-08 153e-07	
6th surface k = -1.081 A4 = -2.8927867 7th surface k = -0.300 A4 = 4.59425c-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802c-23th surface k = 0.000 A4 = 8.84524c-24th surface k = 0.000 A4 = -6.213606	e-04, $A6 = 1$. $e-04$, $A6 = 1$. $e-04$, $A6 = -3$. $e-04$, $A6 = -1$. $e-04$, $A6 = -1$. $e-04$, $A6 = 1$.	34631e-(9990e-06 3.04912e- 69760e-(13249e-(53368e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	08874e-08 .153e-07 .0.23	8	- 40 - 45 - 50 - 55	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.92431e 25th surface k = 0.000 A4 = 8.84524e 26th surface k = 0.000	2e-04, A6 = 1. 2e-04, A6 = 1. 2e-04, A6 = 2. 2e-04, A6 = -1. 2e-04, A6 = -1. 2e-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-06 2.53963e-(94103e-(13249e-(06 06 06 5 -06, A8 = -5 06, A8 = 2.82 05, A8 = 3.91	2007e-08 153e-07	
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e- 17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e- 23th surface k = 0.000 A4 = 8.84524e- 24th surface k = 0.000 A4 = -6.213606 NA Magnifi Focal le	e-04, $A6 = 1$. $e-04$, $A6 = 1$. $e-04$, $A6 = -3$. $e-04$, $A6 = -1$. $e-04$, $A6 = -1$. $e-04$, $A6 = 1$.	34631e-(9990e-06 3.04912e- 69760e-(13249e-(53368e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	0.23 -1.32	8	- 40 - 45 - 50 - 55	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.92431e 25th surface k = 0.000 A4 = 8.84524e 26th surface k = 0.000	2e-04, A6 = 1. 2e-04, A6 = 1. 2e-04, A6 = 2. 2e-04, A6 = -1. 2e-04, A6 = -1. 2e-04, A6 = -1.	84877e-(41106e-(15880e-(4380e-06 2.53963e-(13249e-(53368e-(06 06 06 5 -06, A8 = -5 06, A8 = 2.82 05, A8 = 3.91	2007e-08 153e-07	
6th surface k = -1.081 A4 = -2.89278 7th surface k = -0.300 A4 = 4.59425e- 17th surface k = 0.000 A4 = -2.67915 18th surface k = 0.000 A4 = 3.85802e- 23th surface k = 0.000 A4 = 8.84524e- 24th surface k = 0.000 A4 = -6.213600 NA Magnifi Focal le Image h fb(mm)	e-04, $A6 = 1$. e-04, $A6 = -1$. e-04, $A6 = -1$. e-04, $A6 = -1$. e-04, $A6 = 1$. e-04, $A6 = 1$.	34631e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	0.23 -1.32 -1.32 -1.32 -1.32 -1.32 -1.32	8	- 40 - 45 - 50 - 55 - 60	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.04640e 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.92431e 25th surface k = 0.000 A4 = 8.84524e 26th surface k = 0.000 A4 = -6.21360	e-04, A6 = 1. e-04, A6 = 1. e-04, A6 = 2. e-05, A6 = 1.7 e-04, A6 = -6. e-04, A6 = -1. V	84877e-(41106e-(15880e-(4380e-06 2.53963e-(13249e-(53368e-(06 06 06 5 -06, A8 = -5 06, A8 = 2.82 05, A8 = 3.91	153e-07	
6th surface k = -1.081 A4 = -2.892786 7th surface k = -0.300 A4 = 4.59425e-17th surface k = 0.000 A4 = -2.679156 18th surface k = 0.000 A4 = 3.85802e-23th surface k = 0.000 A4 = 8.84524e-24th surface k = 0.000 A4 = -6.213606 NA Magnifi Focal le Image h fb(mm)	e-04, $A6 = 1$. e-04, $A6 = -1$. e-04, $A6 = -8$. e-04, $A6 = -1$. e-04, $A6 = 1$.	34631e-(06 5 -06, A8 = -1 06, A8 = -2.9 05, A8 = 3.91	0.23 -1.32 -1.32 -1.32 5.34 4.75	8	- 40 - 45 - 50 - 55	k = 0.000 A4 = -2.20622 5th surface k = 0.000 A4 = -2.39825 6th surface k = -1.082 A4 = -2.94477 7th surface k = -0.170 A4 = 9.046406 19th surface k = 0.000 A4 = -1.93247 20th surface k = 0.000 A4 = 3.924316 25th surface k = 0.000 A4 = 8.845246 26th surface k = 0.000 A4 = -6.21366 NA Magnif Focal le	Pe-04, A6 = 1. Pe-04, A6 = 1. Pe-04, A6 = 2. Pe-04, A6 = 1.7 Pe-04, A6 = -6. Pe-04, A6 = -1. Ve-04, A6 = 1.	84877e-(41106e-(15880e-(4380e-06 2.53963e-(13249e-(53368e-(06 06 06 5 -06, A8 = -5 06, A8 = 2.82 05, A8 = 3.91	153e-07 0.23	

	-c	continue	ed					-(continue	ed		
		Unit mm							Unit mm			
fb(mm)	(in air)			1.63		- 5		19th surf	ace			
	tal length(mm) (in air)		42.87		-		k = 0.000 A4 = 5.7 20th surf	3551e-06	5		
	Ex	kample -	43			10		k = 0.000 A4 = 2.9 21th suri	5534e-06	5		
		Unit mm				-		k = 0.000 $A4 = -1$ $22th suri$	18942e-0)6		
		urface dat				15		-				
Surface no.	r	d d	nd	vd	θgf	-		k = 0.000 $A4 = 2.6$ $23th surf$	2449e-06	5		
1 2*	32.668 -16.839	3.43 0.79	1.84666	23.77	0.620			k = 0.000		\c		
3*	-14.534	0.70	1.58364	30.30	0.599	20 _			.59746e-0			
4* 5*	13.753 13.429	0.35 3.98	1.49700	81.61	0.538	_			arious da	ta		
6 7	-19.967 15.031	0.10 3.74	1.49700	81.61	0.538		NA Magnifi	cation			0.23 -1.33	
8* 9	-17.691 17.346	0.30 2.79	1.61800	63.33	0.544	25	Focal le				7.78 4.92	
10	-12.239	0.70	1.72047	34.71	0.583		fb(mm)	(in air)			1.35	
11 12(Stop)	9.694 ∞	1.03 1.14				_	Lens to	tal length(mm) (in air)		48.97	
13 14	-19.591	0.70	1.72047	34.71	0.583							
15	7.666 39.824	2.09 5.19	1.61800	63.33	0.544	30		Ex	ample -	44		
16* 17*	13.644 -18.626	5.65 3.78	1.49700	81.61	0.538							
18*	18.113	2.84	1.63490	23.88	0.630	_						
19* 20*	-72.883 -17.228	4.98 0.70	1.53368	55.90	0.563				Unit mm			
21*	19.172	1.78				35		S	urface dat	a		
22* 23*	-13.391 32.664	0.84 0.80	1.53368	55.90	0.563		Surface no.	r	d	nd	vd	$\theta \mathrm{gf}$
24 25	& &	0.38 0.30	1.51640	65.06	0.535	-	1	36.494	3.32	1.84666	23.77	0.620
Image plane	∞						2* 3*	-16.015 -14.579	0.72 0.71	1.58364	30.30	0.599
	Aspher	rical surfa	ce data			40	4*	16.856	0.41			
	2nd surfa	ісе				_	5* 6	16.777 -15.718	3.81 0.10	1.49700	81.61	0.538
	k = -2.85	52					7 8*	19.072	3.37	1.49700	81.61	0.538
	3rd surfa					- 45	9	-17.469 17.675	0.30 2.70	1.61800	63.33	0.544
	k = 0.000 $A4 = 3.9$) 9545e-06	5			73	10 11	-12.437 8.495	0.70	1.72047	34.71	0.583
	4th surfa					_	12(Stop) 13	∞ -14.896	0.82 0.70	1.72047	34.71	0.583
	k = 0.000)					14 15	10.195 27.848	1.80 1.85	1.61800	63.33	0.544
		80111e-0)4			50	16*	15.325	5.04	1.49700	81.61	0.538
	•					_	17* 18*	-10.454 13.414	9.60 2.88	1.63490	23.88	0.630
	k = 0.023 A4 = -1.	3 98268e-0	04				19* 20*	990.845 -11.800	4.74 0.70	1.53368	55.90	0.563
	8th surfa						21*	51.656	1.21			
	k = -2.94					55	22* 23*	-22.343 18.755	0.70 1.20	1.53368	55.90	0.563
		9124e-05	5				24 25	φ φ	0.38	1.51640	65.06	0.535
	A4 = 1.6 16th surf	ace				_		~	0.50			
	16th surf						Image plane	∞				
	k = -0.5 $A4 = -6.$	79 22198e-0	05			60	Image plane		rical surfa	ce data		
	$16th surf$ $k = -0.5^{\circ}$ $A4 = -6.$ $17th surf$	79 22198e-0 ace	05			60 _	Image plane			ce data		
	$\frac{16\text{th surf}}{k = -0.5}$ $A4 = -6.$ 17th surf $k = 0.000$	79 22198e-0 Tace) 2946e-05				60 -	Image plane	Aspher	1ce 54	ce data		
	$ \begin{array}{r} 16 \text{th surf} \\ k = -0.5' \\ A4 = -6. \\ 17 \text{th surf} \\ k = 0.000 \\ A4 = 1.3 \end{array} $	79 22198e-0 face) 2946e-05 face				60 -	Image plane	Aspher 2nd surfa k = -2.33	ace 54 ce	ce data		

		T Tools was							T Tools many			
		Unit mm					12/6		Unit mm			
	4th surfac	:e				- 5	12(Stop) 13	∞ -15.256	0.85 0.76	1.72047	34.71	0.58
	k = 0.000						14	17.797	1.70	1.61800	63.33	0.54
	A4 = -1.0		04				15	48.679	1.26	1.01000	05.55	0.0
	5th surfac	e					16*	14.757	3.95	1.49700	81.61	0.53
						_	17*	-9.274	14.60			
	k = 0.711						18*	12.062	2.80	1.63490	23.88	0.63
	A4 = -2.0)4			10	19*	97.824	2.82			
	8th surfac	:e				_	20*	-17.861	0.70	1.53368	55.90	0.56
	1- 1.01	0					21*	237.695	1.46	1.52269	55.00	0.50
	k = -1.01 A4 = 6.63		e				22* 23*	-11.342 17.018	0.70 1.20	1.53368	55.90	0.56
	16th surfa		,				24	17.016 ∞	0.38	1.51640	65.06	0.53
	Total Stilla	icc				15	25	∞	0.30	1.510-0	03.00	0.55
	k = -0.57	'9				13	Image plane	00	0.50			
	A4 = -1.1)4			-		A 1	. 1 .	1.4		
	17th surfa	ice						Aspher	rical surfa	ce data		
	k = 0.000 A4 = 3.77		-					2nd surfa	ice			
	18th surfa		,			20		k = -2.10	51			
	1 our surra	ice				-		K = -2.10 3rd surfa				
	k = 0.662											
	A4 = -1.0)5					k = 0.000				
	19th surfa	ice				_			8176e-04	1		
	1 0000					25		4th surfa	ce			
	k = 0.000 A4 = 1.38		=					k = 0.000)			
	20th surfa		,						, 3952e–05			
	2001 80118	ice				_		5th surfa		,		
	k = 0.000											
	A4 = 3.62	2602e-06	5					k = 10.86	55			
	21th surfa	ice				30			41264e-()4		
	1 0000							8th surfa	ce			
	k = 0.000		0.6					1- 1-17	2.1			
	A4 = -2.1 22th surfa		J6					k = -1.12	21 7656e–05			
	22th 8th 1a	ice				_		16th surf		,		
	k = 0.000					35		10011 5011				
	A4 = 4.13		5			33		k = -0.53	79			
	23th surfa								45146e-0)4		
						_		17th surf	ace			
	k = 0.000											
	A4 = -2.8	34367e-0)6					k = 0.000		_		
	T.7:	arious da	to			40		A4 = 5.5 18th surf	3442e-05)		
	Va	irious da	ta			_		18th suri	ace			
NA				0.23				k = 0.704	1			
Magni	ification			-1.33					23220e–()5		
Focal 1	length			7.87				19th surf				
	height(mm)			4.92		45						
	ı) (in air)	. 21		1.75		43		k = 0.000)			
Lens to	otal length(mm)	(in air)		49.02					4431e-06	5		
						-		20th surf	ace			
	-	4	4.5					k = 0.000)			
	Exa	ample -	45			50			, 9150e–06	5		
						50		21th surf				
						_		k = 0.000)			
	τ	Unit mm							1008e-06	5		
	Su	ırface dat	ta			- _ 55		22th surf	ace			
		d	nd	vd	θgf	_ ~~		k = 0.000				
Surface no.	r	-	1.84666			-		A4 = 2.5 $23th surf$	9060e–06 ace	,		
Surface no.	T4.056	2.00		23.77	0.620			1 0.55	`			
Surface no.	74.956	2.98 0.57	1.04000					k = 0.000	J			
1		2.98 0.57 0.70	1.58364	30.30	0.599	60			52002			
1 2* 3* 4*	74.956 -14.732 -12.899 43.976	0.57		30.30		60		A4 = -1.	53883e-(06		
1 2* 3* 4* 5*	74.956 -14.732 -12.899 43.976 33.291	0.57 0.70 0.34 3.01		30.30 81.61	0.599 0.538	60						
1 2* 3* 4* 5* 6	74.956 -14.732 -12.899 43.976 33.291 -17.492	0.57 0.70 0.34 3.01 0.10	1.58364 1.49700	81.61	0.538	60 -			53883e-0 arious da			
1 2* 3* 4* 5* 6 7	74.956 -14.732 -12.899 43.976 33.291 -17.492 15.494	0.57 0.70 0.34 3.01 0.10 3.16	1.58364			60	NA				0.23	
1 2* 3* 4* 5* 6 7	74.956 -14.732 -12.899 43.976 33.291 -17.492 15.494 -22.742	0.57 0.70 0.34 3.01 0.10 3.16 0.30	1.58364 1.49700 1.49700	81.61 81.61	0.538 0.538	60	NA Magnifi	V			0.23	
1 2* 3* 4* 5* 6 7	74.956 -14.732 -12.899 43.976 33.291 -17.492 15.494	0.57 0.70 0.34 3.01 0.10 3.16	1.58364 1.49700	81.61	0.538	60 -	NA Magnifi Focal le	V			0.23 -1.33 7.55	

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	-c	ontinue	ed			-continued						
		Unit mm							Unit m	ım		
fb(mm)	(in air)			1.75		5		19th s	surface			
Lens to	tal length(mm) (in air)		49.05		-			000 1.97223e- surface	-06		
	Ex	ample (46			10			000 4.00526e- urface	-07		
		Unit mm				-		k = 0. $A4 = 0$	000 8. 92606e-	-07		
	Si	urface dat	ta			- 15			surface			
Surface no.	r	d	nd	νd	θgf	_		$\mathbf{k} = 0$.				
1 2*	71.023 -14.922	2.80 0.95	1.84666	23.77	0.620	_			5.45128e- arface	-07		
3* 4*	-12.661 52.837	0.70 0.32	1.58364	30.30	0.599	20		k = 0.	000			
5* 6	34.772 -16.453	2.72 0.10	1.49700	81.61	0.538	_	A4 = -3.69544e-07					
7 8*	17.240 -21.457	2.71 0.30	1.49700	81.61	0.538	_	Various data					
9 10	17.407 -17.609	2.53 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583	25	NA				0.20	
11	7.015	1.23	1.72047	JT./1	0.505			gnification al length			-1.33 7.55	
12(Stop) 13	∞ -16.751	0.75 0.77	1.72047	34.71	0.583		Ima	ge height(mm))		4.92	
14	18.568	1.71	1.61800	63.33	0.544	20	,	nm) (in air)	\ // ·		1.75	
15 16*	54.564 16.776	1.28 3.75	1.49700	81.61	0.538	30	Len	s total length(r	nm) (in ai	r)	49.05	
17*	-8.639	15.60										
18* 19*	12.605 175.251	2.73 2.76	1.63490	23.88	0.630							
20*	-17.864	0.70	1.53368	55.90	0.563				Exampl	e 47		
21* 22*	246.294 -11.062	1.46 0.70	1.53368	55.90	0.563	35			-			
23* 24	16.891 ∞	1.20		65.06								
25	∞	0.38 0.30	1.51640	65.06	0.535	_			Unit m	ım		
Image plane	∞					40 -			Surface	data		
	Aspher	ical surfa	ce data			40 – -	Surface					
	2nd surfa	ice					no.	r	d	nd	νd	θ gf
	k = -2.47 3rd surfa						1 2*	53.186 -15.475	3.31 0.51	1.84666	23.77	0.620
	k = 0.000)				- 45	3* 4*	-15.703 13.712	0.70 0.34	1.58364	30.30	0.599
		2263e-04	1				5* 6	13.464 -19.181	4.14 0.10	1.49700	81.61	0.538
						-	7	17.400	3.90	1.49700	81.61	0.538
	k = 0.000 $A4 = 3.66$) 4682e-05	5			50	8* 9	-17.175 17.131	0.30 2.69	1.61800	63.33	0.544
	5th surfa					_	10	-20.225	0.70	1.72047	34.71	0.583
	k = 13.81	12					11 12	9.630 ∞	1.97 2.03			
	A4 = -1.	65670e-0)4				(Stop)				a · =	_
	8th surfa	ce				_ 55	13 14	-26.870 7.211	0.70 2.12	1.72047 1.61800	34.71 63.33	0.583 0.544
	k = -1.17					55	15	28.975	4.80			
	A4 = 8.1 16th surf	1125e–05 ace	•				16* 17*	14.848 -15.080	5.21 3.09	1.49700	81.61	0.538
						_	18*	17.473	2.77	1.63490	23.88	0.630
	k = -0.57 A4 = -1.	79 27084e-0)4				19* 20*	-177.281 -18.091	4.94 0.70	1.53368	55.90	0.563
	17th surf					60 –	21*	24.560	1.58			
	k = 0.000)					22* 23*	-15.011 19.931	0.70 1.20	1.53368	55.90	0.563
		, 2229e-05	;				24	∞	0.38	1.51640	65.06	0.535
							2.5		0.20			
	18th surf	àce				_	25 Image	& &	0.30			

-cor	

						_						
		Unit mm				_						
	Asphe	erical surfa	ice data			- <u>-</u>	3*	-15.047	0.70	1.58364	30.30	0.59
						- 5	4*	15.659	0.30		04 ***	
	2nd s	urface				_	5* 6	14.778	3.69	1.49700	81.61	0.53
	k = -	2.086					6 7	-22.190 19.531	0.10 4.09	1.49700	81.61	0.53
		urface					8*	-14.652	0.30	1.10/00	01.01	0.55
						-	9	17.123	2.28	1.61800	63.33	0.54
	$\mathbf{k} = 0$					10	10	199.434	0.70	1.72047	34.71	0.58
		-2.15591e	≥ −05				11	10.381	4.19			
	4th sı	urface				_	12	œ	4.31			
	k = 0	000					(Stop) 13	-76.959	0.70	1.72047	34.71	0.58
		−1.47223e	≥-04				14	8.399	2.01	1.61800	63.33	0.54
		urface				15	15	22.390	3.54			
						_	16*	14.258	3.78	1.49700	81.61	0.53
		0.289	0.4				17*	-14.525	2.72	1 (2.400	22.00	0.63
		–1.86447e urface	3-04				18* 19*	14.720 53.371	2.59 4.84	1.63490	23.88	0.63
	our st	шисе				_	20*	-13.285	0.70	1.53368	55.90	0.56
	k = -	1.390				20	21*	25.319	1.55	1100000		0.00
		1.40344e-	-06			20	22*	-14.684	0.89	1.53368	55.90	0.56
	<u>16th</u> :	surface				_	23*	31.963	1.20			
		0.570					24	∞	0.38	1.51640	65.06	0.53
		0.579	. 05				25 Images	8	0.30			
		-6.47710e surface	:-03				Image plane	∞				
	17411	Janace				- 25 _	prane					
	$\mathbf{k} = 0$.000						Asph	erical surfa	ice data		
		1.29548e-	-05			_						
	18th :	surface				_		2nd	surface			
	1.	0.500						1,	0.694			
		0.598 -1.56300e	-06			30			-0.684 surface			
		surface	<i>,</i> –00			20		510 8	urrace			
						-		k = (0.000			
	$\mathbf{k} = 0$.000						A4 =	-8.51383	e-05		
		-1.87807e	è−06					4th s	urface			
	20th :	surface						1- 7	000			
	k = 0	000				35).000 = –1.17461	a 04		
		2.90468e-	-06						urface	J-0 -1		
		surface										
						_			-0.882			
	$\mathbf{k} = 0$								= -1.4947 00	e-04		
		-2.72835e	÷-06			40		8th s	urface			
	22th :	surface				_		l	-0.931			
	k = 0	.000							-0.931 - 1.39588e-	-05		
		2.59014e-	-06						surface	-03		
		surface				_		1001				
			_			- 45		k = -	-0.579			
	k = 0		. 06			40			-3.93181	e-05		
	A4 =	-3.73844e	3-06			_		17th	surface			
	-	Various dat	ta.			_						
						-		k = (
NA				0.23					: 3.73980e-	-05		
	nification			-1.33		50		18th	surface			
	l length			8.00				k = (1.481			
	e height (mm) m) (in air)			4.92 1.75					.461 = 9.25556e-	-07		
	um (m am) total length (m	m) (in air)		49.07					surface			
25110		, (0011)				-			-			
						55		k = (0.000			
									-2.64171	e-06		
	F	xample 4	48					20th	surface			
	ட	ipic	10									
						-		k = ().000 = 4.07916e-	06		
		Unit mm				60			= 4.0 /916e- surface	-00		
						• 00		<u> 21th</u>	surrace			
		Surface dat	īa.			_		k = (0.000			
									-5.47250 	e-06		
Curfac-		,	nd	vd	θ gf				surface			
Surface	r	ď										
Surface no.	r	d	nu	*4	Og1	-						
	r -39350.564	2.80	1.84666	23.77	0.620	65		k = (0.000			

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		-contin	ued						-contin	ued		
		Unit n	ım						Unit n	ım		
	23t	h surface				 - 5		16t	h surface			
		0.000 = -6.3703	36e-06			_		A4	-0.579 = 8.05044 h surface	le-05		
		Various	data									
	gnification al length			0.20 -1.33 7.74		10		A4	0.000 = 9.03489 h surface	9e-05		
Ima fb (i	ge height (mm mm) (in air) s total length (ir)	4.92 1.75 48.87				A4	-0.016 = 3.31417 h surface	e-06		
		Exampl	e 49			- 15		A4	0.000 = -2.160 h surface	71e-06		
						_ 20		A4	0.000 = 2.33119 h surface	9e−06		
		Unit m	ım			_		 ৮_	0.000			
		Surface	data			_		A4	= -5.1179 h surface	99e-06		
Surface no.	r	d	nd	νd	θgf	25		k =	0.000 = 2.87005	ie-06		
1 2*	-759.356 -16.189	2.69 0.67	1.84666	23.77	0.620				h surface			
3*	-15.594	0.70	1.58364	30.30	0.599				0.000			
4* 5*	13.189 12.715	0.30 3.60	1.49700	81.61	0.538	30 _		A4	= -7.5045	59e-06		
6 7	-30.208 18.195	0.10 4.42	1.49700	81.61	0.538	_			Various	data		
8* 9	-14.458 23.874	0.30 1.96	1.61800	63.33	0.544		NA				0.20	
10	58.560	0.70	1.72047	34.71	0.583		Foc	gnification al length			-1.33 7.45	i
11 12	13.172 ∞	5.42 5.58				35		ge height (mm mm) (in air)	1)		4.92 1.76	
(Stop) 13	224.670	0.70	1.72047	34.71	0.583	_		s total length (mm) (in a	ir)	48.85	
14	9.058	2.04	1.61800	63.33	0.544							
15 16*	19.643 9.888	0.90 3.32	1.49700	81.61	0.538	40			Exampl	e 50		
17* 18*	-27.891 9.778	2.58 2.40	1.63490	23.88	0.630	40						
19*	18.665	4.60	1.03490	23.00	0.030							
20*	-8.157	0.70	1.53368	55.90	0.563	_						
21* 22*	2626.112 -9.615	1.31 2.09	1.53368	55.90	0.563	_			Unit m	m		
23*	-515.428	1.20				45			Surface	data		
24 25	& &	0.38 0.30	1.51640	65.06	0.535		Surface					
Image plane	8					_	no.	r	d	nd	νd	θgf
Piane	A	1	rface data			- 50	1*	52.649	2.73	1.84666	23.77	0.620
			riace data			- 50	2* 3	-38.622 -19.976	2.79 2.81	1.65412	39.68	0.574
	<u>2nc</u>	l surface				_	4 5*	30.338 20.044	0.20 4.31	1.49700	81.61	0.538
		-0.608 surface					6 7	-18.337 10.677	0.10 4.30	1.49700	81.61	0.538
	-					₅₅	8*	161.939	0.12			
	A4	0.000 = -9.3558 surface	81e-05				9 10 11	24.169 -32.541 12.119	3.23 0.71 0.91	1.61800 1.72047	63.33 34.71	0.544 0.583
		0.000				_	12	œ	0.15			
	A4	= -1.7049	94e-04			60	(Stop) 13	49.063	0.77	1.90366	31.32	0.595
	<u>5th</u>	surface				_	14 15	7.771 10.588	1.92 0.20	1.61800	63.33	0.544
		-1.128					16*	6.409	4.13	1.49700	81.61	0.538
		= -1.6970 surface	03e-04				17* 18*	-23.504 -223.234	1.62 0.71	1.49700	81.61	0.538
		-1.027				— 65	19* 20*	6.065 20.127	7.57			
		-1.027 = 9.58875	5e-06				21*	-9.164	3.49 2.84	1.58364	30.30	0.599

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						_								
		Unit m	ım			- _								
22*	-13.178	0.79	1.53368	55.90	0.563	5			Unit	mm				
23* 24	11.671 ∞	9.70 0.38	1.51640	65.06	0.535	_			Surfac	ce data				
25	σ σ	0.38	1.31040	03.00	0.333	_			Sana					
Image	∞						Surface no.	r	d	nd	vd	θg		
plane						_ 10 -								
	Aer	herical su	rface data			_ 10	1*	48.290	4.00	1.84666	23.77	0.62		
	- Asi-	80.				_	2* 3	-46.881 -22.804	2.58 1.76	1.65412	39.68	0.57		
	1st surface						4	27.062	0.14					
						_	5* 6	18.619 -19.533	5.28 0.10	1.49700	81.61	0.53		
	k = 0.000 $A4 = 5.94361$	la 05				15	7	10.604	4.45	1.49700	81.61	0.53		
	2nd surface	16-03					8*	131.823	0.10					
	Ziid sariace					_	9 10	23.442	3.28 0.70	1.61800	63.33	0.54		
	k = 0.000						10	-31.030 11.383	1.20	1.72047	34.71	0.58		
	A4 = 5.27712	2e-05					12	00	-0.09					
	5th surface					_ 20	(Stop)	26.227	0.70	1.00255	21.22	0.50		
	l- 0.01.6						13 14	36.337 7.635	0.70 2.06	1.90366 1.61800	31.32 63.33	0.59 0.54		
	k = -0.816 $A4 = -7.3083$	38e-06					15	10.913	0.10	1.01000	05.55	0.54		
	8th surface	J3C-00					16*	6.511	4.50	1.49700	81.61	0.53		
						_ 25	17*	-24.120	1.67					
	k = 0.000					25	18* 19*	-46.412	0.73	1.49700	81.61	0.53		
	A4 = 1.01191	le-04					19* 20*	6.211 16.578	4.33 3.80	1.58364	30.30	0.59		
	16th surface					_	21*	-8.549	2.73	1.0000	55.50	0.00		
	k = -0.579						22*	-9.091	0.70	1.53368	55.90	0.56		
	A4 = -6.6983	35e-05				30	23*	18.805	10.20	1.51.640	CE 0.0	0.53		
	17th surface						24 25	∞ ∞	0.38 0.30	1.51640	65.06	0.53		
						_	Image	∞	0.50					
	k = 0.000						plane							
	A4 = -5.310 18 th surface	17e-05				_			enhovi 1	curface date				
	1 our surrace					- 35 -	Aspherical surface data							
	k = 0.000							1st surface						
	A4 = -5.1171	15e-04						lr = 0.000	· <u></u>					
	19th surface					_		k = 0.000 A4 = 5.837	/31e=05					
	k = 0.000					40		2nd surface						
	A4 = -4.6479	97e-04				70								
	20th surface							k = 0.000	94a 05					
						_		A4 = 5.276 5th surface						
	k = 0.000	• • • •												
	A4 = -2.9252	20 e –04				45		k = -0.912						
	21th surface					_		A4 = -8.58 8th surface						
	k = 0.000							our surface						
	A4 = 1.24424	4e-04						k = 0.000						
	22th surface							A4 = 1.028						
						- 50		16th surfac	e					
	k = 0.000							k = -0.579						
	A4 = 9.16605	5e-05						A4 = -3.17	468e-05					
	23th surface					_		17th surfac	e					
	k = 0.000					55		k = 0.000						
	A4 = -5.1712	29e-04, A	6 = -2.60414	1e-06				A4 = -1.40						
		•				-		18th surfac	e					
		Various	data					k = 0.000						
						-		A4 = -7.46	5576e-04					
N/				0.17		60		19th surfac						
	agnification			-1.40				lr = 0.000						
01	cal length age height (mm	1)		14.81 4.92				k = 0.000 A4 = -6.42	486e-04					
Tres	rage neight (IIIII)	9						A4 = -0.42 20th surfac						
	(mm) (in sir)			10.75				ZOIII SUITAC	-					
fb	(mm) (in air) ens total length (mm) (in a	ir)	10.25 56.63		65		k = 0.000						

		-contin	ueu						-contin	lueu					
		Unit m	ım				Unit mm								
	21th surface					_ _ 5		5th surface							
	k = 0.000 A4 = 1.5459 22th surface	6e-04				_ 3	k = -0.834 A4 = -2.83924e-06 8th surface								
	k = 0.000 A4 = 1.25420 23th surface	0e-04				10	k = 0.000 10 A4 = 1.05701e-04 16th surface								
	k = 0.000 $A4 = -5.644$	64e-04, A	6 = -5.63513	3e-07		_	k = -0.579 A4 = -6.90189e-05 17th surface								
		Various	data			- 15		k = 0.000							
						_		A4 = -5.4780 18th surface	08e-05						
Fo In fb	A (agnification ocal length nage height (mm (mm) (in air) ens total length (ir)	0.20 -1.33 14.41 4.92 10.75 55.55	: : :	20		k = 0.000 A4 = -4.860 19th surface k = 0.000	35e-04						
			<u>, </u>			25		$A4 = -5.426$ $\underline{20th \ surface}$ $k = 0.000$	65e-04						
		Exampl	e 52					A4 = -3.045 $21 th surface$	26e-04						
		Unit m	ım			30		k = 0.000 A4 = 2.66622 22th surface	2e-05						
		Surface	data			_		k = 0.000							
Surface no.	rface							A4 = -2.0983 $23th surface$	38e-04						
1*	51.478	3.20	1.84666	23.77	0.620	35		k = 0.000 A4 = -6.852	69e-04, A	6 = -2.12762	2e-06				
2* 3 4	-38.560 -19.565 30.186	2.65 3.38 0.21	1.65412	39.68	0.574	_			Various	data					
5*	19.873	4.50	1.49700	81.61	0.538		NA				0.17	,			
6 7	-18.633 10.628	0.10 4.21	1.49700	81.61	0.538	40		gnification cal length			-1.40 15.30				
8*	212.692	0.10	1.42700	01.01	0.550			age height (mm	1)		4.92				
9	24.897	3.19	1.61800	63.33	0.544			(mm) (in air)	7		12.25				
10	-30.693	0.70	1.72047	34.71	0.583		Lei	ns total length (mm) (in a	ir)	58.05	i			
11	12.401	0.90				_									
12 (Stop)	∞	0.10				45									
(Stop) 13	55.667	0.70	1.90366	31.32	0.595				Examel	2.52					
14	7.805	1.84	1.61800	63.33	0.544				Exampl	C 33					
15	10.579	0.30													
16*	6.428	4.02	1.49700	81.61	0.538										
17* 18*	-23.103	1.57	1 40700	01 (1	0.520										
18** 19*	-110.480 6.147	0.70 6.35	1.49700	81.61	0.538	50			Unit m	ım					
20*	17.957	3.44	1.58364	30.30	0.599				Surface	data					
21*	-9.569	2.94				_									
22*	-11.357	0.70	1.53368	55.90	0.563		Surface								
23* 24	14.587 ∞	11.70 0.38	1.51640	65.06	0.535	_	no.	r	d	nd	νd	θ gf			
2 4 25	∞ ∞	0.30	1.51040	00.00	0.555	55 —	1*	70.275	2.70	1.84666	23.77	0.620			
Image plane	8	0.50					2* 3	-30.659 -17.537	2.30 2.26	1.65412	39.68	0.574			
	Asr	herical su	rface data			-	4 5*	35.866 27.673	0.35 3.95	1.49700	81.61	0.538			
						- 60	6	-17.104	0.10						
	1st surface					_	7 8*	9.747 162.593	3.94 0.10	1.49700	81.61	0.53			
	k = 0.000						9	24.099	3.09	1.61800	63.33	0.544			
	A4 = 6.6171	6e-05					10	-26.964	0.70	1.72047	34.71	0.583			
	2nd surface					_	11	12.683	0.88						
							12	∞	0.07						
	k = 0.000					65	(Stop)		0.70	1.00000	21.00	A =4			
	A4 = 5.9722	2e-05					13	64.816	0.70	1.90366	31.32	0.595			

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						_								
		Unit m	ım			_								
14 15	7.829 10.768	1.84 0.10	1.61800	63.33	0.544	5			Unit mm					
16*	6.611	3.23	1.49700	81.61	0.538			:	Surface dat	a				
17* 18* 19*	-21.476 -267.827 6.489	1.33 0.70 6.45	1.49700	81.61	0.538		Surface no.	r	d	nd	νd	θgf		
20* 21*	23.224 -9.742	3.31 3.29	1.58364	30.30	0.599	10	1* 2*	51.478 -38.560	3.20 2.65	1.84666	23.77	0.620		
22* 23*	-7.668 185.012	0.70 13.20	1.53368	55.90	0.563		3	-19.565 30.186	3.38 0.21	1.65412	39.68	0.574		
24 25	& &	0.38 0.30	1.51640	65.06	0.535		5* 6	19.873 -18.633	4.50 0.10	1.49700	81.61	0.538		
Image plane	∞					15	7 8*	10.628 212.692	4.21 0.10	1.49700	81.61	0.538		
	Asp	herical sur	rface data			_	9	24.897	3.19	1.61800	63.33	0.544		
						_	10 11	-30.693 12.401	0.70 0.90	1.72047	34.71	0.583		
	1st surface						12 (Stop)	00 00	0.10					
	1 0.000						13	55.667	0.70	1.90366	31.32	0.595		
	k = 0.000 A4 = 9.37043	05				20		7.805	1.84	1.61800	63.33	0.544		
	A4 = 9.37043 $2nd surface$	e-03					15	10.579	0.30					
	zna surrace						16*	6.428	4.02	1.49700	81.61	0.538		
	k = 0.000						17*	-23.103	1.57	1 40700	01 71	0.53		
	A4 = 8.05222	le-05					18* 19*	-110.480 6.147	0.70 6.35	1.49700	81.61	0.53		
	5th surface						20*	17.957	3.44	1.58364	30.30	0.59		
							21*	-9.569	2.94	1.50504	30.30	0.57.		
	k = 0.415						22*	-11.357	0.70	1.53368	55.90	0.56		
	A4 = 9.29789	⁄e−06					23*	14.587	11.70					
	8th surface					_	24	∞	0.38	1.51640	65.06	0.53		
	1 0.000						25	8	0.30					
	k = 0.000 A4 = 1.46231	.e-04				30	Image plane	∞						
	16th surface					_		Aspherical surface data						
	k = -0.579 $A4 = -1.6050$)7e=04						1st surface						
	17th surface					_ 35		k = 0.000 A4 = 6.61716e-05						
	k = 0.000 A4 = 1.24501	.e-04						2nd surface						
	18th surface					_		k = 0.000 A4 = 5.97222e-0	5					
	k = 0.000							5th surface	,					
	A4 = -1.0875	6e-04				40		3th stirace						
	19th surface							k = -0.834						
	1- 0.000					_		A4 = -2.83924e-	06					
	k = 0.000 A4 = -6.9965	i4e-04						8th surface						
	20th surface					45		k = 0.000						
	k = 0.000					-		A4 = 1.05701e-0- 16th surface	4					
	A4 = -3.0802	8e-04												
	21th surface					_		k = -0.579	0.5					
	1- 0.000							A4 = -6.90189e -	US					
	k = 0.000 A4 = -1.1493	35e-04				50		17th surface						
	22th surface					_		k = 0.000						
	1 0.000							A4 = -5.47808e -	US					
	k = 0.000 $A4 = -6.5385$	50° 04						18th surface						
	A4 = -6.5385 23th surface	10C-U4						k = 0.000						
	25th surface					_ 55		A4 = -4.86035e	04					
	k = 0.000	72- 04-7	C (44015	0.7				19th surface	- •					
	A4 = -9.3477	•		:-U/		_		k = 0.000						
	Various data							A4 = -5.42665e - $20th surface$	04					
				0.17				1 0000						
NA NA				-1.40				k = 0.000	0.4					
Ma	agnification							A4 = -3.04526e						
Ma Fo	cal length	`		15.97					04					
Ma Foo Im	cal length age height (mm)		4.92				21th surface						
Mε Foo Im fb	cal length		ir)			65			0 4					

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		193	1						19			
	-(continue	eu .			_			-conti			
		Unit mm				_			Unit	mm		
	22th surface					– 5		14th surface				
	k = 0.000 A4 = -2.09838e - 0 23th surface)4						k = -0.579 A4 = 2.14569e 16th surface	-05, A6 =	8.56596e-07		
	k = 0.000 $A4 = -6.85269e-0$)4, A6 = -2	2.12762e-06	i		10		k = 0.000 A4 = -1.21434 17th surface	e-05			
	V	/arious dat	a					k = 0.000				
	NA Magnification			0.17 -1.40		- 15		A4 = 1.82906e 18th surface	-06			
	Focal length Image height (mm) fb (mm) (in air) Lens total length (mr	n) (in air)		15.30 4.92 12.25 58.05				k = 0.000 A4 = -5.24617 19th surface	'e-05			
	zens total rengal (im	ii) (iii uii)		30.03		20		k = 0.000 A4 = -1.13335 20th surface	e-06			
	E	xample :	55					k = 0.000 A4 = 1.01208e 21th surface	-05			
						_ 25		k = 0.000				
		Unit mm				-		A4 = -2.49639 $23th surface$	e-05			
Surface no.	r	Surface dat d	a nd	νd	θgf	-		k = 0.000 $A4 = -2.94354$	e-05, A 6	= -6.86427e-06		
1*	25.913	2.07	1.84666	23.77	0.620	- 30			Various	data		
2* 3*	31.151 17.097	0.30 6.09	1.49700	81.61	0.538			NA			0.23	
4 5	-111.014 16.382	0.10 3.66	1.49700	81.61	0.538			Magnification Focal length			-1.10 12.36	
6*	76.965	0.10				35]	Image height (mn	n)		4.92	
7 8	12.471 -19.985	5.23 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583			fb (mm) (in air) Lens total length	(mm) (in	air)	2.72 44.83	
9 10 (Stop)	10.437 ∞	1.53 -0.40										
11	15.326	0.70	1.90366	31.32	0.595							
12 13	5.760 7.466	2.24 0.10	1.61800	63.33	0.544	40			Examp	le 56		
14*	5.529	3.20	1.49700	81.61	0.538							
15 16*	-250.000 -31.020	0.93 1.06	1.49700	81.61	0.538							
17*	6.332	2.81							Unit ı	nm		
18* 19*	13.296 -8.640	4.02 0.80	1.58364	30.30	0.599	45			Surface	data		
20*	-7.506	4.48	1.53368	55.90	0.563		~ .					
21* 22	-8.795 -11.302	0.39 2.00	1.53368	55.90	0.563		Surface no.	r	d	nd	vd	θgf
23*	23.373 ∞	2.15	1.51640	65.06	0.535		1 2	22.916 44.302	1.51 0.00	1.60999 1001.00000	27.48	0.620
24 25	& &	0.38 0.31	1.31040	65.06	0.535	50	3	44.302	0.20	1.63762	-3.45 34.21	0.296 0.594
Image plane	∞						4 5*	44.214 11.892	0.75 4.50	1.49700	81.61	0.538
	Asphe	rical surfa	ce data			_	6	-75.023	0.10	1.49700	61.01	0.558
	1st surface					-	7 8*	16.979 35.199	2.78 0.71	1.49700	81.61	0.538
	-					- 55	9	19.063	2.75	1.61800	63.33	0.544
	k = 0.000 A4 = 9.25518e-06 2nd surface	5				_	10 11 12 (Stop)	-18.581 33.626 ∞	0.77 1.26 0.30	1.72047	34.71	0.583
	k = 0.000 A4 = 8.47403e-06 3rd surface	5				60	13 14 15 16*	29.197 5.383 9.288 6.872	0.83 1.47 0.91 3.01	1.90366 1.61800 1.49700	31.32 63.33 81.61	0.595 0.544 0.538
						_	17*	12.602	1.91			
	k = -0.200 A4 = 2.89370e - 06	5					18* 19*	-9.053 -10.553	3.06 0.91	1.49700	81.61	0.538
	6th surface					_	20* 21*	12.072 -24.825	3.90 1.94	1.58364	30.30	0.599
	k = 0.000					65	22*	-19.526	1.01	1.49700	81.61	0.538
	A4 = 6.07603e - 05)					23*	11.127	7.48			

196 Example 57

						•	Unit mm							
24*	-59.537	1.12	1.53368	55.90	0.563	5								
25* 26	19.034 ∞	1.10 0.38	1.51640	65.06	0.535				Surface	data				
27 mage plane	& &	0.41	101010				Surface no.	r	d	nd	νd	θgf		
	Ası	herical su	rface data			10	1* 2*	14.849 24.251	2.81 1.16	1.84666	23.77	0.620		
	5th surface					•	3* 4	11.029 -159.692	2.65 0.10	1.49700	81.61	0.538		
						-	5	24.766	1.11	1.60999	27.48	0.620		
	k = -0.513						6	25.004	0.00	1001.00000	-3.45	0.29		
	A4 = -1.393976	e-05				15	7	25.005	0.20	1.63762	34.21	0.59		
	8th surface					13	8 9	24.343	0.11	1 61900	62.22	0.54		
						-	10	16.634 -14.550	2.86 0.72	1.61800 1.72047	63.33 34.71	0.54		
	k = 0.000						11	28.345	0.72	1.72047	J 4 ./1	0.56		
	A4 = 7.69283e	-05					12 (Stop)	20.5 4 5	-0.05					
	16th surface						13	28.631	0.72	1.90366	31.32	0.59		
					20		6.286	1.64	1.61800	63.33	0.54			
	k = -0.579						15	14.078	5.35					
	A4 = -1.272456					16*	7.582	3.02	1.49700	81.61	0.53			
	17th surface						17*	14.928	8.00					
	17th surface					_	18*	15.671	3.78	1.58364	30.30	0.59		
							19*	-20.144	1.79					
	k = 0.000					25	20*	-10.482	0.70	1.49700	81.61	0.53		
	A4 = -2.001476 18 th surface	e-04					21*	8.846	3.50					
	18th surface						22*	13.317	2.28	1.53368	55.90	0.56		
						-	23*	9.855	2.70					
	k = 0.000						24	∞	0.38	1.51640	65.06	0.53		
	A4 = -1.964826	04					25	∞	0.30					
	19th surface				30	Image plane	∞							
	k = 0.000			-		Aspherical surface data								
	k = 0.000 $A4 = -5.46173e-07$							1st surface						
	20th surface					- 25		k = 0.000						
						35		A4 = 1.89575e	-05					
	k = 0.000							2nd surface						
	A4 = -4.977016	e-05												
	21th surface							k = 0.000						
						-		A4 = 2.05342e	-05					
	k = 0.000					40		3rd surface						
	A4 = 5.00869e-	-05				40								
	22th surface	0.5						k = -1.001						
	ZZIII SUITACE					_		A4 = -2.79051	.e-05					
								16th surface						
	k = 0.000													
	A4 = -1.31586	e-04				45		k = -0.579						
	23th surface					70		A4 = -9.97074	le-05					
						_		17th surface						
	k = 0.000													
	A4 = -1.81687	e-04						k = 0.000						
	24th surface							A4 = 4.56155e	:-0 5					
	2 rai bailace					- 50		18th surface						
	k = 0.000							'						
		0.4						k = 0.000						
	A4 = -3.305476	8-04						A4 = -1.55616	5e-04					
	25th surface					-		19th surface						
	k = 0.000					55		k = 0.000						
	A4 = -3.69284	e-04, A6 =	-2.84789e-06					A4 = -9.53455	5e-05					
		Various	data			•		20th surface						
		+ arrous	ww.ut			-		k = 0.000 A4 = 6.03104e	-05					
N	JΑ			0.20		60			-05					
	lagnification			-1.56		00		21th surface						
	Magnification -1.56 Focal length 7.72							k = 0.000						
	_	.)		4.92				A4 = 5.76196e	-05					
Ir	nage height (mn	ı)							-03					
~	o (mm) (in air)			1.76				22th surface						
	ens total length	mm) (in a	ir)	44.95		65		k = 0.000						

100

		19	7						19	8		
		-conti	nued						-conti	nued		
		Unit	mm			•			Unit	mm		
	23th surface					- - 5						
	k = 0.000 A4 = -1.67453	se-04, A 6	= -3.57134e-06			_		k = 0.000 A4 = -9.14712 18th surface	2e-05, A6	= 5.79438e-07		
		Variou	s data					-				
]	NA Magnification Focal length			0.20 -1.60 8.33		10		k = 0.000 A4 = -2.04464 19th surface	1e-04			
i	Image height (mr fb (mm) (in air) Lens total length		air)	4.92 3.25 46.16		- 15		k = 0.000 A4 = 3.63528e 24th surface	:-05			
		Examp	ole 58			- 15		k = 0.000 A4 = -3.43309 25th surface	9e-05			
						20		k = 0.000 A4 = -4.64396	бе-04			
		Unit	mm						Variou	s data		
		Surface	data			_		NA			0.23	
Surface no.	r	d	nd	νd	θgf	_ 25		Magnification Focal length Image height (mr	n)		-1.33 9.33 4.92	
1* 2*	23.262 191.812	3.28 1.33	1.84666	23.77	0.620			fb (mm) (in air) Lens total length	(mm) (in	a i m	3.86 54.14	
3	53.883 14.902	0.50 0.14	1.62588	35.70	0.589			Lens total length	(IIIIII) (III	an)	34.14	
5* 6	13.978 -29.978	5.96 0.10	1.49700	81.61	0.538	30			Examp	Ja 50		
7 8*	15.765 510.224	3.37 0.10	1.49700	81.61	0.538				Lamp	one 39		
9 10	32.798	3.12 0.50	1.61800 1.72047	63.33 34.71	0.544 0.583							
11	-19.809 12.325	1.78	1.72047	34./1	0.363				Unit	mm		
12 (Stop)	∞	0.78	1.002.66	21.22	0.505	35						
13 14	-140.812 9.869	0.50 2.61	1.90366 1.61800	31.32 63.33	0.595 0.544		-		Surface	e data		
15	113.862	2.42	1.01000	03.33	0.5 11		Surface no	. r	d	nd	vd	$\theta g f$
16* 17*	11.277 -59.524	3.74 8.10	1.49700	81.61	0.538		1*	22.101	3.18	1.84666	23.77	0.620
18*	-3485.657	0.70	1.49700	81.61	0.538		2*	124.650	0.30	1.04000	23.77	0.020
19*	9.598	0.46	21.157.00	02.02		40	3	114.152	0.70	1.62588	35.70	0.589
20	9.139	5.57	1.60999	27.48	0.620		4	16.412	0.30			
21	-16.931	0.00	1001.00000	-3.45	0.296		5*	13.305	5.99	1.49700	81.61	0.538
22	-16.932	0.20	1.63762	34.21	0.594		6	-31.233	0.30			
23	-49.525	3.11	1 52260	55.00	0.562		7	17.773	3.61	1.49700	81.61	0.538
24* 25*	-7.878 24.022	1.91 3.30	1.53368	55.90	0.563	45	8* 9	-77.787 40.293	0.30 3.15	1.61800	63.33	0.544
26	24.022 ∞	0.38	1.51640	65.06	0.535		10	-16.251	0.70	1.72047	34.71	0.583
27	∞	0.31	_10 10 10				11	16.421	1.03			
Image plane	∞						12 (Stop)	∞	0.57			
						•	13	-40.907	0.70	1.90366	31.32	0.595
	As	pherical s	urface data				14	9.293	3.10	1.61800	63.33	0.544
	1st surface					- 50	15 16*	-40.883 12.708	1.32 2.72	1.60999	27.48	0.620
	15t surface					-	17	27.809	0.00	1001.00000	-3.45	0.020
	k = 0.000						18	27.809	0.20	1.63762	34.21	0.594
	A4 = 1.21996e	-05					19*	27.322	6.28			
	2nd surface					_	20*	28.448	1.49	1.49700	81.61	0.538
	1 0.000					55	21*	12.258	7.34	1.500.5	20.20	0.500
	k = 0.000 A4 = 2.73727e	. 05					22* 23*	10.768 -26.410	3.89	1.58364	30.30	0.599
	A4 = 2.73727e 5th surface	-05					24*	-26.410 -9.722	3.22 0.95	1.53368	55.90	0.563
	Jan Surface					-	25*	10.802	3.19	1.55500	22.20	V.202

A4 = -1.19710e-05 8th surface k = 0.000A4 = 3.40041e - 0516th surface

k = -0.165

k = -0.579A4 = -1.81901e - 05, A6 = 2.18274e - 07

Aspherical surface data 1st surface

 ∞

8

60

65

26 27 Image plane

0.38

0.30

1.51640

65.06

0.535

k = 0.000A4 = 1.81664e - 05

a* 1
-confinited

-continue	

		Unit:	mm			•			Unit m	m		
	2nd surface					•	12	-51.065	0.70	1.72047	34.71	0.583
	k = 0.000					- 5	13	11.329	1.50			
	A4 = 3.178676	-05					14 (Stop) 15	∞ 29.773	-0.25 0.70	1.90366	31.32	0.595
	5th surface						16	8.337	3.21	1.61800	63.33	0.544
	1 0.470						17	36.482	1.31	4 40500	04.64	
	k = -0.472 A4 = -1.54652	2e_05				10	18* 19*	10.000 108.943	3.43 5.30	1.49700	81.61	0.538
	8th surface	26-03				10	20*	-760.614	0.70	1.49700	81.61	0.538
						-	21*	12.153	8.57			
	k = 0.000	0.7					22*	10.932	4.26	1.58364	30.30	0.599
	A4 = 2.70940e 16th surface	=-05					23* 24*	-46.469	4.54 0.75	1.53368	55.90	0.563
	Tour surface					15	25*	-10.332 15.919	2.85	1.33308	33.90	0.30.
	k = -0.579					13	26	∞	0.38	1.51640	65.06	0.53
	A4 = 5.377236	=-05, A6 =	= 1.28843e-06				27	∞	0.30			
	19th surface					-	Image plane	∞				
	k = 0.000	05.46	1.50100- 06					As	pherical sur	face data		
	$A4 = 7.641306$ $\underline{20th \ surface}$	=03, A0 =	= 1.39199e-06			20		1st surface				
	k = 0.000											
	A4 = 2.385746	-05						k = 0.000	06			
	21th surface					_		A4 = 9.77276e	-06			
	k = 0.000					25		2nd surface				
	A4 = -5.41583	le-05						k = 0.000				
	22th surface							A4 = 1.67764e	-05			
	1 0000							5th surface				
	k = 0.000 A4 = -9.20996	Sa_05						k = -0.659				
	23th surface	JE-03				30						
	20 th bithage					-		A4 = 1.08105e 18th surface	-03			
	k = 0.000							1041 5411400				
	A4 = 1.487656 24th surface	-05						k = -0.579				
	24th surface					-		A4 = 5.63637e	-06, A6 = 3	5.19107e-07		
	k = 0.000					35		19th surface				
	A4 = 2.307986	-04						k = 0.000				
	25th surface					-		A4 = 2.26706e	-06, A6 = 0	5.14099e-07		
	k = 0.000							20th surface				
	A4 = -1.65854	1e-04										
		Various	e data			40		k = 0.000 $A4 = -3.93066$	ia 06			
		Various	s uata					21th surface	ic-00			
	NA			0.23								
	Magnification			-1.33				k = 0.000				
	Focal length Image height (mi	m)		10.42 4.92				A4 = 1.90962e	-06			
	fb (mm) (in air)			3.74		45		22th surface				
	Lens total length	(mm) (in	air)	55.07				k = 0.000				
						-		A4 = -3.81502	e-05			
								23th surface				
		Examp	ole 60					1 0.000				
		•				50		k = 0.000 A4 = 2.47354e	-06			
								24th surface	00			
		Unit	mm					k = 0.000 A4 = 7.91457e	-06 A6-	I 44833e-06		
		Surface	e data			_ 55		25th surface	50,110 -			
Surface no.	r	d	nd	vd	$\theta g f$			k = 0.000		2.10/=2		
1*	30.853	3.59	1.84666	23.77	0.620			A4 = -1.11135	e-05, A6 =	=-2.19459e-00)	
2* 3	-228.348 34.422	0.30 0.70	1 62500	35.70	0.589				Various	data		
4	34.422 14.782	0.70	1.62588	33.70	0.589	60						
5*	12.104	6.41	1.49700	81.61	0.538			NA			0.23	
6	-35.889	0.30						Magnification			-1.33	
7	-49.464 49.078	0.20	1.63762	34.21	0.594			Focal length Image height (mr	n)		10.62 4.92	
8	-49.078 -49.077	0.00 0.70	1001.00000 1.60999	-3.45 27.48	0.296 0.620			fb (mm) (in air)	,		3.41	
9						65		Lens total length	(mm) (in ai	r)	55.07	
9 10	-60.906	0.30						Lens total length	(mmi) (m a	1)	33.07	

201 Example 61

202 -continued

		•				_			Ontina			
									Unit mm	1		
		Unit mm				- 5	18th surface					
	S	urface da	ta			-	k = 0.132					
Surface no.	r	d	nd	νd	θgf	-	A4 = 6.922446 19th surface	:-06, A6 = 6.1	9572e-01	7, A8 = 8.384	66e-09	
1* 2*	-8.586 -38.013	6.54 0.08	1.53368	55.90	0.563	10	k = -2.887 A4 = 8.207446	:-06, A6 = -4.	23855e-0	07, A8 = 2.80	030e-09	
3* 4*	23.658	5.62	1.63490	23.88	0.630		20th surface					
5* 6*	-13.749 483.930 31.754	0.05 0.50 0.05	1.58364	30.30	0.599		k = -0.631 A4 = -4.16331e-06, A6 = -1.26465e-07, A8 = -9.14719e-09					
7*	10.006	6.19	1.49700	81.61	0.538	15	21th surface					
8 * 9	-22.587 36.901	0.05 4.56	1.61800	63.33	0.544	13	k = -1.191 A4 = 5.22955e	05 46 - 4	06780a (77 48 - 10	15876a 00	1
10 11	-9.647 15.812	0.50 1.63	1.72047	34.71	0.583		$\frac{22 \text{th surface}}{22 \text{th surface}}$	-03, A0 = -4.	007896=0	57, A6 = -1.0	36706-05	
12(Stop)	∞	0.83					k = -31.151					
13	-23.387	0.50	1.72047	34.71	0.583	20	A4 = 7.85252e	=05, A6 = -4	81367e-0	07, A8 = -3.4	5006e-09),
14 15	18.752	3.04	1.61800	63.33	0.544	20	A10 = 2.89579			,		,
15 16*	-24.584 13.844	0.12 5.92	1.49700	81.61	0.538		23th surface					
10** 17*	-20.251	5.92 9.46	1.49/00	01.01	0.538		-					
18*	-20.231 -10.122	5.91	1.58364	30.30	0.599		k = -0.713					
19*	-10.122 -13.868	2.45	1.50504	50.50	∪. JJJ		A4 = -4.71492		4.75038e-	-08, A8 = -1	.74975e-1	10,
20*	-9.722	7.60	1.58364	30.30	0.599	25	A10 = -7.9736	50e-12				
21*	-7.658	3.02	1.0000	50.50	0.000	25	24th surface					
22*	-16.164	3.70	1.63490	23.88	0.630							
23*	-27.524	0.05	2100 15 0		0.000		k = -4.264					
24*	7.572	5.94	1.53368	55.90	0.563		A4 = -3.18002		39934e-0	06, A8 = 7.25	578e-09,	
25*	3.912	6.00					A10 = -5.3975	94e-11				
26	œ	0.30	1.51640	65.06	0.535	30	25th surface					
27	∞	6.28				30	1- 1 001					
Image plane	∞					_	k = -1.881 $A4 = -3.56331$		70132e-0	06, A8 = -5.3	2334e-08	3,
	Asphei	rical surfa	ce data				A10 = 2.10863e-10					
1st surface						- 35 -		V	arious da	ıta		
k = 0.580						33	NA				0.60	
A4 = -9.12075	e-04 A6 = 5	362630_0	05 48 = -36	16360_06	6		Magnif	ication			-3.57	
2nd surface	C 04, 210 = 3.	302030	<i>55</i> ,210 = -5.0	710300 00	,		Focal le				8.96	
Ziid Bill lidee						_		height(mm)			7.93	
k = 0.348) (in air)			12.47	
A4 = -6.71325	e-04, $A6 = 4$.	96564e-0	06, A8 = -1.0)2244e-07	7	40	Lens to	tal length(mm	i) (in air)		86.77	
3rd surface												
k = -0.448												
A4 = 2.69179e	-05, $A6 = 2.5$	9561e-07	7. A8 = 1.810	93e-09				Ex	cample	62		
4th surface	05,110 215	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,,,,,	,,,,					-			
						45						
k = -2.729						73						
A4 = 2.62358e- 5th surface	-05, A6 = 1.6	6698e-06	5, A8 = -5.24	204e-09		_			Unit mm			
k = -2409.520						- <u>-</u>		S	urface da	ta		
A4 = -5.88015 6th surface	e-06, A6 = -:	5.65544e-	-08			50	Surface no.	r	d	nd	vd	θgf
k = 0.023							1*	-8.518	6.48	1.53368	55.90	0.563
K = 0.023 A4 = 8.78714e-	-06 A6 = 4 0	340900)				2*	-38.017	0.07			
A4 = 8.787146 7th surface	-vo, Au = 4.9	シーログビーロジ	,				3*	23.626	5.62	1.63490	23.88	0.630
, ai suitace						_	4*	-13.766	0.05			
k = -2.423						55	5*	474.790	0.49	1.58364	30.30	0.59
A4 = -3.77237	e-05, $A6 = -1$	3.90286⊳-	-07, $A8 = 6.1$	4283e=09	9		6 *	31.840	0.05			
8th surface	- 00,210		J, 110 - 0.1	2050 05	-		7*	9.994	6.43	1.49700	81.61	0.53
						_	8*	-22.550	0.06	1.61000	62.22	0.51
k = 1.443							9	37.796	4.55	1.61800	63.33	0.544
A4 = -3.05033	e-05, A6 = 1.	08600e-0	07, A8 = 1.41	866e-09			10	-9.723	0.50	1.72047	34.71	0.583
16th surface	,	\	,			60	11	15.791	1.51			
						_	12(Stop)	22.405	0.83	1.73047	24.71	0.50
k = -1.658							13	-23.405	0.50	1.72047	34.71	0.58
A4 = -1.51099	e-05. A6 = 1	28932e=0	97, A8 = -7.2	26513e-10)		14 15	18.836	3.04	1.61800	63.33	0.54
17th surface	, – 1.		,	10	-		15 16*	-24.432 13.826	0.05	1.40700	81.61	0.529
						_	16* 17*	13.826 -20.280	5.68 9.47	1.49700	81.61	0.538
k = 0.184						65	18*	-20.280 -10.093	5.91	1.58364	30.30	0.599
	e=05 A6 = 1	7 200334	-08 A8 - 43	15546a_10	1		19*			1.50504	50.50	0.395
A4 = -2.43950	e-05, A6 = -	7.20933e-	-08, A8 = 4.7	5546e-10	J		19*	-13.913	3.08			

		203 continue	ed.					-0	204 continue	ьd		
		Unit mm						-(Unit mm			
204	~			2000	0.50		23th overface		Omt Hill			
20* 21*	-9.681 -7.639	7.68 3.02	1.58364	30.30	0.599	5	23th surface					
22*	-16.165	3.77	1.63490	23.88	0.630		k = -0.621					
23*	-27.283	0.05					A4 = -4.77440		4.56224e-	-08, A8 = -8	.13918e-1	1,
24*	7.584	5.93	1.53368	55.90	0.563		A10 = -7.8957 $24th surface$	ZC-1Z				
25*	3.906	6.00	1.51.610	65.06	0.535		2 5411400					
26 27	∞ ∞	0.30 5.82	1.51640	65.06	0.535	10	k = -4.243					
Image plane		3.62				_	A4 = -3.18831 A10 = -5.0517		.39907e=0	96, A8 = 7.38	3731e-09,	
	Asphe	rical surfa	ice data			_	$\frac{25\text{th surface}}{k = -1.870}$					
1st surface						_ 15	A4 = -3.34225 A10 = 2.31442		.68135e=0	6, A8 = -5.4	12846e-08	3,
k = 0.475						_						
A4 = -8.844 2nd surface	441e-04, A6 = 6	.04064e-(05, A8 = -5.7	76698e-06	5	_	271	7	/arious dat	ta	0.50	
1 0.050							NA Magnif	ication			0.60 -3.56	
k = -0.958	3132e-04, A6 = 5	. 041036	06 A8 = =1 9	03257a_0	7	20	Focal le				8.92	
A4 = -0.08 3rd surface	1520-04, Ato = 3	1036-	00, A0 = -1.	UDZD/6-U	,		Image l	height(mm)			7.93	
						_		(in air)	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		12.02	
k = -0.479							Lens to	tal length(mn	1) (in air)		86.83	
A4 = 2.6630 4th surface	01e-05, A6 = 2.4	17046e-07	7, A8 = 1.704	74e-09		25						
k = -2.726 A4 = 2.6264 5th surface	40e-05, A6 = 1.6	57016e-06	5, A8 = -5.41	971e-09				Ez	xample	63		
l. 2245.0	775					- 30 -						
k = -2345.8 A4 = -5.834	3/5 422e-06, A6 =	4 851184	-08			50 =			Unit mm			
6th surface		051100-						S	Surface da	ta		
k = -0.006 A4 = 8.6883	36e-06, A6 = -4.	.70192e-()9			_	Surface no.	r	d	nd	νd	θg
7th surface						35	1*	-7.039	4.91	1.53368	55.90	0.56
1- 2.425							2*	-17.920	0.05			
k = -2.425	595e-05, A6 = -	2 9/1974-	07 49 59	264462 00	n		3*	15.584	4.58	1.63490	23.88	0.63
A4 = -3.773 8th surface),);=-03, A0 = -	J.0 4 0/46-	-01, Ao = 3.8	,0 -11 0e-05	,		4* 5*	-12.462	0.05	1.40700	Q1 <i>C</i> 1	0.53
- III BUITACE						_	5* 6*	6.979 -19.498	3.28 0.05	1.49700	81.61	0.53
k = 1.450						40	7	39.995	2.50	1.61800	63.33	0.54
	845e-05, A6 = 1.	.01828e-0	97, A8 = 1.52	990e-09			8	-7.177	0.50	1.72047	34.71	0.58
16th surface							9	9.843	0.80			
						_	10(Stop)	∞	0.58			
k = -1.658					_		11	-13.844	0.50	1.72047 1.61800	34.71 63.33	0.58
	124e-05, $A6 = 1$.26975e-(57, A8 = -7.2	28488e-10)	45	12 13	9.243 -20.574	2.44 0.05	1.01600	03.33	0.54
17th surface						_	14*	10.818	3.74	1.49700	81.61	0.53
k = 0.179							15*	-12.062	13.98			
	938e-05, A6 = -	6.94876e-	-08. A8 = 3 9	98116e-10)		16*	-6.434	6.53	1.58364	30.30	0.59
18th surface		5.5 15700	50,210 - 5.5	51100 10	~		17*	-5.371	3.16	1 (2 (0)	22.00	0.7-
						- 50	18* 19*	-11.488 -18.115	1.97 0.27	1.63490	23.88	0.63
k = 0.132						30	20*	-18.113 5.193	3.81	1.53368	55.90	0.56
	69e-06, $A6 = 6.3$	2887e-07	7, A8 = 9.679	25e-09			21*	2.478	4.35	1.55500	22.50	0.50
19th surface						_	22	œ	0.26	1.51640	65.06	0.53
l. 3.000							23	00	0.91			
k = -2.890 A4 = 8.4098	85e-06, A6 = -4	16581e. 0	07 A8 - 202	048e=00			Image plane	00				
20th surface		.105016-0	, , , , , , , , , , , , , , , , , , ,	.0700-09		55 - -		Asphe	rical surfa	ce data		
k = -0.632						_	1st surface					
	651e-06, A6 = -	1.34905e-	-07, A8 = -9	.44213e-(09		k = -7.688					
21th surface	•						A4 = -5.30828	8e-03, A6 = 1	.00779e-0	3, A8 = -3.1	13102e-04	ļ
k = -1.191						60	2nd surface					
	13e-05, A6 = -4	.02486e-0	07, A8 = -1.0)5494e=09	9							
22th surface			, 1.0	02			k = 9.824	So 02 46 2	02575- 6)5 AO 1 1	7205- 04	
						-	A4 = -1.93476 3rd surface	be-0.5, $A6 = 2$.	.833/3e=(0.5, A8 = -1.2	27395e-06)
k = -30.784	ļ						Jiu surface					
	79e-05, $A6 = -4$.73842e-0	97, A8 = -3.4	5074e-09	θ,	65	k = -1.316					
A10 = 2.805	530e-12						A4 = 3.98817e	-05, A6 = 1.7	′5107e–07	V, A8 = 2.542	38e-08	
A10 = 2.805	,		,		,			-05, A6 = 1.7	75107e-07	V, A8 = 2.542	238e-08	

continued continued

	-(continue	ed					-0	continue	ed		
		Unit mm							Unit mm			
4th surface						 - 5	8	-8.538	0.50	1.72047	34.71	0.583
k = -5.068	04.46.67	2445~ 04	: AP 101	602- 07		- 3	9 10(Stop)	11.099 ∞	0.96 0.66	1 72047	24.71	0.592
A4 = 1.22657e- 5th surface	-04, A0 = 0.7	34436-00), A8 = -1.01	603e-07		_	11 12 13	-15.771 10.927 -21.930	0.50 2.65 0.05	1.72047 1.61800	34.71 63.33	0.583 0.544
k = -2.319 A4 = -8.13599	e-05, A6 = -	6.40124e-	-06, A8 = 1.4	3467e-01	7	10	14* 15*	12.592 -13.902	4.04 15.89	1.49700	81.61	0.538
6th surface						_	16* 17*	-7.470 -6.239	7.77 3.85	1.58364	30.30	0.599
k = 3.388 A4 = -1.26292 14th surface	e-04, A6 = -	1.27410e-	-06, A8 = 9.0	1790e-08	3		18* 19* 20*	-13.303 -20.860 6.006	2.40 0.30 4.42	1.63490 1.53368	23.88 55.90	0.630
k = -2.381 A4 = -1.37296 15th surface	e-04, A6 = 1.	.42467e-(06, A8 = -9.0	1579e-09)	15	21* 22 23 Image plane	2.794	5.00 0.30 0.53	1.51640	65.06	0.535
k = -0.582						-		Aspher	rical surfa	ce data		
$A4 = -2.02116$ $\underline{16\text{th surface}}$	e-05, A6 = -	1.14010e-	-06, A8 = -9	.41687e-()9 	20	1st surface					
k = -0.049 A4 = -2.66503 17th surface	e-04, A6 = 1.	.37620e-()5, A8 = -2.7	/5338e=01	7	_	k = -6.559 A4 = -3.0779 2nd surface	8e-03, A6 = 7.	19063e-0)4, A8 = -1.4	13633e−04	1
k = -1.101 A4 = 2.02237e- 18th surface	-04, A6 = -2.	.08688e-()6, A8 = -2.4	8953e-08	3	25	k = 8.617 A4 = -1.2485 3rd surface	9e-03, A6 = 1.	39145e-(05, A8 = -4.3	33338e-01	7
k = -33.992 A4 = 2.88723e A10 = -8.2506 19th surface		.74254e-(06, A8 = -5.4	5486e-08	3,	30	k = -1.217 A4 = 2.14714e-05, A6 = 4.97776e-07, A8 = 6.93013e-09 4th surface					
k = -1.062 A4 = -1.89497 A10 = -3.2488		2.28174e-	-07, A8 = -1	.72532e-0	08,	_	k = -5.042 A4 = 7.672956 5th surface	e-05, A6 = 3.4	2831e-06	5, A8 = -3.37	7151e-08	
20th surface $k = -4.642$ $A4 = -1.21065$ $A10 = -1.8400$		21481e-0)5, A8 = 1.80	222e-07,		_ 35	k = -2.297 A4 = -6.0472 6th surface	1e-05, A6 = -3	3.09153e-	-06, A8 = 4.8	34282e-08	3
21th surface						_ 40	k = 3.319 A4 = -8.2834	8e-05, A6 = -0	6.61324e-	-07, A8 = 3.2	24620e-08	3
k = -1.845 A4 = -8.86076 A10 = 2.99535		.64728e-(05, A8 = -1.4	8831e-06	5,	40	$\frac{14\text{th surface}}{k = -2.342}$	· 				
		⁄arious da	ta			-		9e-05, A6 = 8.	36992e-0	97, A8 = -4.4	15060e-09)
NA Magnifi Focal le Image l				0.60 -3.56 4.98 4.75		45	k = -0.501 A4 = -1.6222 16th surface	0e-05, A6 = -5	5.10344e-	-07, A8 = -3	.96678e-I	09
fb(mm) Lens to	(in air) tal length(mm	ı) (in air)		5.43 59.20		- 50	k = -0.081 $A4 = -1.7472$ 17th surface	0e-04, A6 = 6.	86575e-0	06, A 8 = -9.7	76272e-08	3
	Example 64						k = -1.090 $A4 = 1.45428$ 18th surface	e-04, A6 = -1.	07366e-0	06, A8 = -5.7	76918e-09)
		Unit mm				- 55	k = -35.703 A4 = 2.125386	e-04, A6 = -2.	80559e=0)6. A8 = -1 8	32100e=0	3.
		urface da				- -	A10 = -2.498 19th surface			-,110 - 110		.,
Surface no.	r	d	nd	νd	$\theta g f$	60	k = -1.240					
1* 2*	-8.599 -19.840	5.93 0.05	1.53368	55.90	0.563	_	A4 = -1.2496 A10 = -7.301	4e-04, A6 = -2 48e-11	2.05558e-	-07, A8 = -4	.46527e-	09,
3* 4*	17.840 -14.375	5.28 0.06	1.63490	23.88	0.630		20th surface					
5* 6* 7	7.961 -22.188 52.926	3.54 0.05 2.61	1.49700 1.61800	81.61 63.33	0.538	65	k = -4.876 $A4 = -8.7053$ $A10 = -2.878$	3e-04, A6 = 5. 01e-10	71807e-0	06, A8 = 5.33	8843e-08,	

	-0	continue	ed				-continued		
		Unit mm					Unit mm		
21th surface						- 5	5th surface		
k = -1.928 A4 = -3.56431 A10 = 3.89803	,	04471e-(05, A8 = -2.6	50 887e –07	7,	_	k = -1871.246 A4 = -1.46877e-05, A6 = -2.79488e-07 6th surface		
	V	arious da	ta			10	k = -0.064 A4 = 2.14004e-05, A6 = 4.39293e-08		
fb(mm)	ength height(mm)	ı) (in air)		0.60 -3.56 5.34 5.50 5.73 67.24		15	7th surface k = -2.423 A4 = -9.35989e-05, A6 = -1.73930e-06, A8 = 5.12031e-08 8th surface k = 1.436 A4 = -7.63094e-05, A6 = 4.05361e-07, A8 = 1.19948e-08 16th surface		
	E>	ample	65			20	k = -1.670 A4 = -3.89307e-05, A6 = 5.41575e-07, A8 = -3.89066e-09 17th surface	1	
		Unit mm				- 25	k = 0.072 A4 = -6.09183e-05, A6 = -2.19847e-07, A8 = 6.07739e-09		
	S	urface da	ta			_	18th surface		
Surface no.	r	d	nd	νd	θgf	_	k = 0.089 A4 = 9.88125e-06, A6 = 2.25429e-06, A8 = 5.40413e-08		
1* 2*	-6.269 -27.398	4.80 0.05	A4 = 9.88125e-06, A6 = 2.25429e-06, A8 = 5.40413e-08 1.53368 55.90 0.563 19th surface						
3* 4* 5*	17.424 -10.162 329.227	4.12 0.05 0.61	1.63490 1.58364	23.88	0.630		k = -2.920 A4 = 2.34541e-05, A6 = -1.70730e-06, A8 = 1.38533e-08 20th surface		
6* 7* 8* 9	23.639 7.301 -16.656 26.802	0.05 4.38 0.05 3.49	1.49700 1.61800	81.61 63.33	0.538 0.544	35	k = -0.618 A4 = -1.37263e-05, A6 = -1.25116e-06, A8 = -8.15675e-0	18	
.0 .1 .2(Stop)	-7.076 11.663 ∞	0.50 1.25 0.71	1.72047	34.71	0.583		21th surface k = -1.185		
13 14 15	-16.523 14.445 -18.236	0.50 2.57 0.06	1.72047 1.61800	34.71 63.33	0.583 0.544	40	A4 = 1.29062e-04, A6 = -1.87858e-06, A8 = -1.27341e-08 22th surface		
16* 17* 18*	10.173 -14.804 -7.554	4.62 6.97 4.14	1.49700 1.58364	81.61 30.30	0.538 0.599		k = -30.535 A4 = 2.12596e-04, A6 = -2.32471e-06, A8 = -3.18933e-08	,	
19* 20* 21*	-9.958 -7.176 -5.830	2.28 4.95 2.02	1.61421	25.60	0.621	45	A10 = 2.49260e-11 23th surface		
22* 23* 24* 25*	-11.735 -20.945 5.546	2.84 0.05 4.33	1.63490 1.53368	23.88 55.90	0.630		k = 0.060 A4 = -1.34020e-04, A6 = -1.76460e-07, A8 = 8.51270e-10 A10 = -1.31091e-10	,	
26 27	2.897 ∞ ∞	4.50 0.30 3.63	1.51640	65.06	0.535	50	24th surface k = -4.296		
Image plane	∞ Asphei	rical surfa	ce data			-	A4 = -8.13846e-04, A6 = 6.17276e-06, A8 = 7.50056e-08, A10 = -7.01350e-10		
1st surface						-	25th surface		
x = 0.659 A4 = -2.04816 2nd surface	se-03, A6 = 2.	35320e-()4, A8 = -4.8	31520e-05	5	55 	k = -1.860 A4 = -8.20694e-04, A6 = 2.77718e-05, A8 = -5.24812e-07 A10 = 5.58526e-09	,	
x = -1.065 A4 = -1.68684	e-03, A6 = 2.	29728e-(05, A8 = -9.2	5180e-01	7	60	Various data		
3rd surface x = -0.588 A4 = 6.51788e 4th surface	-05, A6 = 1.1	3163e-06	5, A8 = 1.957	24e-08		_	NA 0.60 Magnification -3.56 Focal length 6.16 Image height(mm) 5.50 fb(mm) (in air) 8.33		
k = -2.720	05 16 76	6272 - 04	5, A8 = -3.86	820e=08		65	Lens total length(mm) (in air) 6.3.71		

210 -continued

									TT 1.				
						-	18th surface		Unit mm				
		Unit mm				5							
		urface dat				-	k = 0.116 A4 = 6.47632e 19th surface	-06, A 6 = 1.9	3794e-06	, A8 = 8.754	30e-08		
Surface no.	r	d	nd	vd	θgf	-	k = -2.967						
1* 2*	-6.744 -28.324	4.55 0.05	1.53368	55.90	0.563	10	A4 = 3.57609e 20th surface	-05, A6 = -1.	49735e-0	6, A8 = 2.83	588e-08		
3* 4*	17.647 -10.252	4.11 0.05	1.63490	23.88	0.630		-						
5* 6*	368.125 23.485	0.70 0.05	1.58364	30.30	0.599		k = -0.611 A4 = -1.58294e-05, A6 = -1.07032e-06, A8 = -9.97644e-08						
7*	7.303	3.75	1.49700	81.61	0.538	15	21th surface						
8 * 9	-16.608 27.992	0.05 3.48	1.61800	63.33	0.544	10	k = -1.189 A4 = 1.28670e-04, A6 = -1.99874e-06, A8 = -1.23533e-08						
10 11	-7.240 11.712	0.50 0.93	1.72047	34.71	0.583		A4 = 1.28070e 22th surface	-04, A0 = -1.	998/46-0	10, A8 = -1.2	33336-00		
12(Stop)	11./12 ∞	0.93											
13	-16.247	0.50	1.72047	34.71	0.583		k = -30.969		50011 0		4400 00		
14	14.941	2.48	1.61800	63.33	0.544	20	A4 = 2.14284e		50014e-0	10, A8 = -3.9	4482e-08	,	
15	-17.172	0.05					A10 = 1.75181	c-11					
16*	10.250	5.04	1.49700	81.61	0.538		23th surface						
17*	-14.686	7.09					k = 0.274						
18*	-7.433	3.40	1.58364	30.30	0.599		A4 = -1.40593	e-04. A6 = -1	2.34596e-	07. A8 = -2	72736e=0	9.	
19*	-10.047	2.59		0.5.50	0.000		A4 = -1.40393 A10 = -1.3426			07,2102.	., 2, 500-0	,	
20*	-6.674	5.39	1.61421	25.60	0.621	25	24th surface						
21*	-5.707	2.10	1 63 400	22.00	0.630		5011000						
22*	-11.710	2.68	1.63490	23.88	0.630		k = -4.460						
23* 24*	-20.113 5.560	0.08	1 52260	55.90	0.562		A4 = -8.31533	e-04, A6 = 6.	06058e-0	6, A8 = 7.30	319e-08,		
24* 25*	5.560	4.27	1.53368	33.90	0.563		A10 = -5.3858				-,		
25** 26	2.881 ∞	4.50 0.30	1.51640	65.06	0.535		25th surface						
26 27	∞	2.87	1.51040	05.00	0.555	30							
Image plane	∞	2.07					k = -1.870						
0- r		ical surfa	ce data			-	A4 = -7.81641 A10 = 6.43070		80809e-0	15, A8 = -5.7	2873e-07	' ,	
1 ot ourfees	Aspilei	icai sui la	ee uaid				Various data						
1st surface						- 35 -							
k = 0.466							NA				0.60		
A4 = -1.831136	e-03, A6 = 2.	20399e-0	94, A8 = -4.0	1986e-05	5		Magnif	ication			-3.56		
2nd surface			<i>'</i>										
							Focal le	ength			5.82		
						_	Image l	ength neight(mm)			5.23		
						-	Image l fb(mm)	ength neight(mm) (in air)) (in air)		5.23 7.57		
A4 = -1.673026	e-03, A6 = 2.	41417e-0	95, A8 = -9.1	4504e-07	7	- 40 -	Image l fb(mm)	ength neight(mm)) (in air)		5.23		
k = -4.154 A4 = -1.673026 3rd surface k = -0.713	e-03, A6 = 2.	41417e-0	95, A8 = -9.1	4504e-07	7	40 _	Image l fb(mm)	ength neight(mm) (in air) tal length(mm			5.23 7.57		
A4 = -1.673026 3rd surface k = -0.713			<u> </u>		7	40 _	Image l fb(mm)	ength neight(mm) (in air) tal length(mm) (in air)	67	5.23 7.57		
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e			<u> </u>		7	40 _	Image l fb(mm)	ength neight(mm) (in air) tal length(mm		67	5.23 7.57		
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-			<u> </u>		7	- -	Image l fb(mm)	ength neight(mm) (in air) tal length(mm		67	5.23 7.57		
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e- 4th surface k = -2.747	-05, A6 = 1.2	1873e-06	i, A8 = 2.058	95e-08	7	40 _	Image l fb(mm)	ength neight(mm) (in air) tal length(mm		67	5.23 7.57		
A4 = -1.673026 3rd surface	-05, A6 = 1.2	1873e-06	i, A8 = 2.058	95e-08	7	- -	Image l fb(mm)	ength neight(mm) (in air) tal length(mm		67	5.23 7.57		
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e- 4th surface k = -2.747 A4 = 6.54960e-	-05, A6 = 1.2	1873e-06	i, A8 = 2.058	95e-08	7	- -	Image l fb(mm)	ength neight(mm) (in air) tal length(mm) Ex	cample (5.23 7.57		
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.513226	-05, A6 = 1.2 -05, A6 = 7.6	1873e-06	i, A8 = 2.058 i, A8 = -3.72	95e-08	7	- -	Image l fb(mm)	ength neight(mm) (in air) tal length(mm) Ex	cample (5.23 7.57	θgf	
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $4th$ surface $4th$ surface $4th$ surface $4th$ surface $4th$ surface $4th$ surface	-05, A6 = 1.2 -05, A6 = 7.6	1873e-06	i, A8 = 2.058 i, A8 = -3.72	95e-08	7	- 45 	Image I fb(mm) Lens to Surface no.	ength neight(mm) (in air) tal length(mm) Ex	Cample (Unit mm	a	5.23 7.57 62.10	θgf 0.563	
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $k = -2888.742$ $A4 = -1.513226$ $6th$ surface $k = -0.115$	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06	5, A8 = 2.058 5, A8 = -3.72	95e-08	7	- 45 	Image I fb(mm) Lens to	ength neight(mm) (in air) tal length(mm) Ex	Cample (Unit mm urface dat	a nd	5.23 7.57 62.10 vd		
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $k = -2888.742$ $A4 = -1.513226$	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06	5, A8 = 2.058 5, A8 = -3.72	95e-08	7	- 45 	Image I fb(mm) Lens to Surface no. 1* 2* 3*	ength neight(mm) (in air) tal length(mm) Ex S r -11.654 -53.270 32.497	Unit mm urface dat d 8.90 0.09 7.73	a nd	5.23 7.57 62.10 vd		
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $k = -2888.742$ $A4 = -1.513226$	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06	5, A8 = 2.058 5, A8 = -3.72	95e-08	7	- 45 	Image I fb(mm) Lens to Surface no. 1* 2* 3* 4*	Expended to the sent of the se	Unit mm urface dat d 8.90 0.09 7.73 0.05	nd 1.53368 1.63490	vd 55.90 23.88	0.563 0.630	
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $4th$ surface	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06	5, A8 = 2.058 5, A8 = -3.72	95e-08	7	- 45 	Surface no. 1* 2* 3* 4* 5*	Extension to the state of the s	Unit mm urface dat 8.90 0.09 7.73 0.05 0.55	nd 1.53368	5.23 7.57 62.10 vd 55.90	0.563	
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $4th$ surface	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06 1.13362e-	5, A8 = 2.058 6, A8 = -3.72	95e-08 649e-08		45 50 -	Surface no. 1* 2* 3* 4* 5* 6*	Extension (in air) (i	Unit mm urface dat d 8.90 0.09 7.73 0.05 0.55 0.05	nd 1.53368 1.63490 1.58364	vd 55.90 23.88 30.30	0.563 0.630 0.599	
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $k = -2888.742$ $A4 = -1.513226$	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06 1.13362e-	5, A8 = 2.058 6, A8 = -3.72	95e-08 649e-08		45 50 -	Surface no. 1* 2* 3* 4* 5* 6* 7*	Extension (in air) (in air) (in air) (in air) (and in air	Unit mm urface dat d 8.90 0.09 7.73 0.05 0.55 0.05 8.70	nd 1.53368 1.63490	vd 55.90 23.88	0.563 0.630	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.513226 6th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06 1.13362e-	5, A8 = 2.058 6, A8 = -3.72	95e-08 649e-08		45 50 -	Image I fb(mm) Lens to Surface no. 1* 2* 3* 4* 5* 6* 7* 8*	Extension to the state of the s	Unit mm urface dat 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05	nd 1.53368 1.63490 1.58364 1.49700	vd 55.90 23.88 30.30 81.61	0.563 0.630 0.599 0.538	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.5132266th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.1884168th surface	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1	1873e-06 3953e-06 1.13362e-	5, A8 = 2.058 6, A8 = -3.72	95e-08 649e-08		45 50 -	Image I fb(mm) Lens to Surface no. 1* 2* 3* 4* 5* 6* 7* 8*	Expended to the control of the contr	Unit mm d 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26	nd 1.53368 1.63490 1.58364 1.49700 1.61800	vd 55.90 23.88 30.30 81.61 63.33	0.563 0.630 0.599 0.538 0.544	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.513226 6th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416 8th surface k = 1.359	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4.	1873e-06 3953e-06 1.13362e- 40257e-0	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08		45 50 -	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9	Example sight (mm) (in air) tal length (mm) (in air) tal length (mm) Example sight (mm) E	Unit mm urface dat 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50	nd 1.53368 1.63490 1.58364 1.49700	vd 55.90 23.88 30.30 81.61	0.563 0.630 0.599 0.538	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2.888.742 A4 = -1.513226 5th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416 8th surface k = 1.359 A4 = -7.731416	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4.	1873e-06 3953e-06 1.13362e- 40257e-0	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08		45 50 -	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11	Example sength seight (mm) (in air) (in air) tal length (mm) Example sength (mm) Examp	Unit mm urface dat d 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50 2.42	nd 1.53368 1.63490 1.58364 1.49700 1.61800	vd 55.90 23.88 30.30 81.61 63.33	0.563 0.630 0.599 0.538 0.544	
A4 = -1.673026 $3rd$ surface $k = -0.713$ $A4 = 6.22862e$ $4th$ surface $k = -2.747$ $A4 = 6.54960e$ $5th$ surface $k = -2888.742$ $A4 = -1.513226$ $A4 = -1.51326$	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4.	1873e-06 3953e-06 1.13362e- 40257e-0	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08		45 - 45 - 50 - 55 - 55	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11 12(Stop)	Extension to the state of the s	Unit mm urface dat 8.90 0.09 7.73 0.05 0.55 0.05 6.26 0.50 2.42 1.14	a nd 1.53368 1.63490 1.58364 1.49700 1.61800 1.72047	vd 55.90 23.88 30.30 81.61 63.33 34.71	0.563 0.630 0.599 0.538 0.544 0.583	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.513226 6th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4.	1873e-06 3953e-06 1.13362e- 40257e-0	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08		45 - 45 - 50 - 55 - 55	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11 12(Stop) 13	Ength enight(mm) (in air) tal length(mm) Ex S r -11.654 -53.270 32.497 -18.865 609.908 43.689 13.655 -30.942 54.201 -13.279 21.817 6 -31.961	Unit mm d 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50 2.42 1.14 0.52	a nd 1.53368 1.63490 1.58364 1.49700 1.61800 1.72047 1.72047	vd vd 55.90 23.88 30.30 81.61 63.33 34.71 34.71	0.563 0.630 0.599 0.538 0.544 0.583	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.513226 6th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416 8th surface k = 1.359 A4 = -7.731416 16th surface	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4 e-05, A6 = -1	1873e-06 3953e-06 1.13362e- 40257e-C	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08 375e-08	}	45 - 45 - 50 - 55 - 55	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11 12(Stop) 13 14	Example sight (mm) (in air) tal length (mm) (in air) tal length (mm) Example sight (mm) E	Unit mm d 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50 2.42 1.14 0.52 4.08	a nd 1.53368 1.63490 1.58364 1.49700 1.61800 1.72047	vd 55.90 23.88 30.30 81.61 63.33 34.71	0.563 0.630 0.599 0.538 0.544 0.583	
A4 = -1.673026 $A4 = -1.673026$ $A4 = -0.713$ $A4 = 6.22862e$ $A4 = 6.22862e$ $A4 = 6.54960e$ $A4 = 6.54960e$ $A4 = -1.513226$ $A4 = -1.51326$ $A4 = -1.51326$ $A4 = -1.616$ $A4 = -1.661$ $A4 = -1.661$ $A4 = -1.661$	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4 e-05, A6 = -1	1873e-06 3953e-06 1.13362e- 40257e-C	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08 375e-08	}	45 - 45 - 50 - 55 - 55	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11 12(Stop) 13 14	Example sight (mm) (in air) tal length (mm) (in air) tal length (mm) Example sight (mm) E	Unit mm urface dat 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50 2.42 1.14 0.52 4.08 0.15	nd 1.53368 1.63490 1.58364 1.49700 1.61800 1.72047 1.61800	vd 55.90 23.88 30.30 81.61 63.33 34.71 34.71 63.33	0.563 0.630 0.599 0.538 0.544 0.583 0.583 0.544	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2.888.742 A4 = -1.513226 6th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416 8th surface k = 1.359 A4 = -7.731416 16th surface k = -1.661	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4 e-05, A6 = -1	1873e-06 3953e-06 1.13362e- 40257e-C	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08 375e-08	}	45 - 45 - 50 - 55 - 55	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11 12(Stop) 13 14 15 16*	Extension to the state of the s	Unit mm urface dat d 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50 0.242 1.14 0.52 4.08 0.15 8.40	a nd 1.53368 1.63490 1.58364 1.49700 1.61800 1.72047 1.72047	vd vd 55.90 23.88 30.30 81.61 63.33 34.71 34.71	0.563 0.630 0.599 0.538 0.544 0.583	
A4 = -1.673026 3rd surface k = -0.713 A4 = 6.22862e-4th surface k = -2.747 A4 = 6.54960e-5th surface k = -2888.742 A4 = -1.513226 6th surface k = -0.115 A4 = 2.12292e-7th surface k = -2.422 A4 = -9.188416 8th surface k = 1.359 A4 = -7.731416 16th surface k = -1.661 A4 = -3.808586	-05, A6 = 1.2 -05, A6 = 7.6 e-05, A6 = -1 -05, A6 = -4 e-05, A6 = -1	1873e-06 3953e-06 1.13362e- 40257e-C	5, A8 = 2.058 6, A8 = -3.72 -07 -08 -06, A8 = 4.5	95e-08 649e-08 375e-08	}	45 - 45 - 50 - 55 - 55	Surface no. 1* 2* 3* 4* 5* 6* 7* 8* 9 10 11 12(Stop) 13 14	Example sight (mm) (in air) tal length (mm) (in air) tal length (mm) Example sight (mm) E	Unit mm urface dat 8.90 0.09 7.73 0.05 0.55 0.05 8.70 0.05 6.26 0.50 2.42 1.14 0.52 4.08 0.15	nd 1.53368 1.63490 1.58364 1.49700 1.61800 1.72047 1.61800	vd 55.90 23.88 30.30 81.61 63.33 34.71 34.71 63.33	0.563 0.630 0.599 0.538 0.544 0.583 0.583 0.544	

	-(continue	cu					-	continue	ed .		
		Unit mm				_			Unit mm			
20*	-13.249	10.54	1.58364	30.30	0.599	- 5	23th surfac	e				
21* 22*	-10.558 -22.376	4.39 5.26	1.63490	23.88	0.630	-	k = -1.442					
23*	-37.463	0.05	1.05420	23.66	0.050			5838e-05, A6 = -	-1.59948e-	-08, $A8 = -2$.14349e-1	1.
24*	10.448	8.01	1.53368	55.90	0.563		A10 = -4.1	· · · · · · · · · · · · · · · · · · ·	11033 100	00,110 2		-,
25*	5.391	8.22					24th surfac	e				
26 27	∞ ∞	0.30	1.51640	65.06	0.535	10						
Image plane		8.21					k = -4.203					
		. 10 0	1.			-	A4 = -1.26 A10 = -3.2	5702e-04, A6 = 3 27718e-12	3.03286e-0	77, A8 = 8.98	650e-10,	
	Asphei	rical Surfa	ce data			-	25th surfac	ce				
1st surface						_ 15	k = -1.867					
k = 1.075 A4 = -3.07742 2nd surface	e-04, A6 = 9.	.46748e-0	6, A8 = -3.9	9 5246e –07	,		A4 = -1.38 A10 = 1.39				34639e-09	,
k = 0.243						20		•	Various dat	a		
A4 = -2.62486	e-04. A6 = 1.	.05472e-0	6. A8 = -1.1	2886e-08	3	20	NA				0.60	
3rd surface	, 1.	0	, - 1.1	50				ification			-3.55	
						_	_	length			12.29	
k = -0.422	05 46 40	0.657 60	10 2127	£1. 10			_	height(mm)			10.82	
A4 = 1.05645e-	-05, A6 = 4.9	9657e-08	A8 = 2.125	51e-10		25	,	n) (in air)			16.62	
4th surface						- 23	Lens t	total length(mm)	(in air)		119.56	
k = -2.716 A4 = 1.02640e- 5th surface	-05, A6 = 3.3	6920e-07	, A8 = -5.29	009e-10		_						
k = -1981.989 A4 = -2.50643 6th surface	e-06, A6 = -	1.03156e–	08			30		E	Example (58		
k = 0.024									Unit mm			
A4 = 3.45165e- 7th surface	-06, A6 = -4.	.51348e-1	1			35			Surface dat	a		
/til sullace						-	Surface no.	r	d	nd	vd	θgf
k = -2.412 $A4 = -1.51250$	e-05, A6 = -	7.89064e-	08, A8 = 6.6	3287e-10)		1* 2*	-63.538 32.204	10.02	1.85135	40.10	0.56
8th surface						40	3*	32.533	7.00	1.53368	55.90	0.56
8th surface						40	4*		0.26			
k = 1.432								-106.297				
k = 1.432 A4 = -1.17703	e-05, A6 = 2.	.100 26e –0	8, A8 = 1.62	417e-10			5*	54.300	10.00	1.49700	81.61	0.53
8th surface k = 1.432 A4 = -1.17703 16th surface	e-05, A6 = 2.	.10026e-0	8, A8 = 1.62	417e-10		_				1.49700 1.49700	81.61 81.61	
k = 1.432 A4 = -1.17703 16th surface	e-05, A6 = 2.	.10026e-0	8, A8 = 1.62	417e-10		_	5* 6* 7* 8*	54.300 -23.738 85.904 -97.520	10.00 0.98 4.20 0.06			0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632						- 45	5* 6* 7* 8* 9*	54.300 -23.738 85.904 -97.520 105.081	10.00 0.98 4.20 0.06 8.88			0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995						45	5* 6* 7* 8* 9*	54.300 -23.738 85.904 -97.520 105.081 -33.023	10.00 0.98 4.20 0.06 8.88 0.42	1.49700 1.63490	81.61 23.88	0.53 0.63
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface						- 45 -	5* 6* 7* 8* 9*	54.300 -23.738 85.904 -97.520 105.081	10.00 0.98 4.20 0.06 8.88	1.49700	81.61	0.53 0.63
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162	e-06, A6 = 2.	.72227e-0	8, A8 = -7.6	0562e-11		45	5* 6* 7* 8* 9* 10* 11* 12* 13	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68	1.49700 1.63490 1.58364 1.49700	81.61 23.88 30.30 81.61	0.53 0.63 0.59 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741	e-06, A6 = 2.	.72227e-0	8, A8 = -7.6	0562e-11		45	5* 6* 7* 8* 9* 10* 11* 12* 13	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75	1.49700 1.63490 1.58364	81.61 23.88 30.30	0.53 0.63 0.59 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface	e-06, A6 = 2.	.72227e-0	8, A8 = -7.6	0562e-11		_	5* 6* 7* 8* 9* 10* 11* 12* 13 14	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53	1.49700 1.63490 1.58364 1.49700	81.61 23.88 30.30 81.61	0.53 0.63 0.59 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151	e-06, A6 = 2.	.72227e-0 1.49326e-	8, A8 = -7.6	0562e-11		_	5* 6* 7* 8* 9* 10* 11* 12* 13	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75	1.49700 1.63490 1.58364 1.49700	81.61 23.88 30.30 81.61	0.53 0.63 0.59 0.53 0.58
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e	e-06, A6 = 2.	.72227e-0 1.49326e-	8, A8 = -7.6	0562e-11		_	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368	81.61 23.88 30.30 81.61 34.71 55.90	0.53 0.63 0.59 0.53 0.58
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e	e-06, A6 = 2.	.72227e-0 1.49326e-	8, A8 = -7.6	0562e-11		_	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700	81.61 23.88 30.30 81.61 34.71 55.90 81.61	0.53 0.63 0.59 0.53 0.58 0.56 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e	e-06, A6 = 2.	.72227e-0 1.49326e-	8, A8 = -7.6	0562e-11		_	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 8.92 8.41	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71	0.53 0.63 0.59 0.53 0.56 0.53 0.58
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e 19th surface k = -2.829	e-06, A6 = 2. e-06, A6 =	.72227e-0 1.49326e- 15693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446	00562e-11 00257e-11 21e-10		- 50	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700	81.61 23.88 30.30 81.61 34.71 55.90 81.61	0.53 0.63 0.59 0.53 0.56 0.53 0.58
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e 19th surface k = -2.829 A4 = 3.81519e	e-06, A6 = 2. e-06, A6 =	.72227e-0 1.49326e- 15693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446	00562e-11 00257e-11 21e-10		_	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.58
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e 19th surface k = -2.829 A4 = 3.81519e 20th surface	e-06, A6 = 2. e-06, A6 =	.72227e-0 1.49326e- 15693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446	00562e-11 00257e-11 21e-10		- 50	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.58 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e 19th surface k = -2.829 A4 = 3.81519e 20th surface k = -0.623	e-06, A6 = 2. e-06, A6 = -1. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 5693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10		- 50	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.58 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e-19th surface k = -2.829 A4 = 3.81519e-20th surface k = -0.623 A4 = -2.50444	e-06, A6 = 2. e-06, A6 = -1. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 5693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10		- 50	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78	0.53 0.59 0.53 0.58 0.56 0.53 0.58 0.53
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e-19th surface k = -2.829 A4 = 3.81519e-20th surface k = -0.623 A4 = -2.50444	e-06, A6 = 2. e-06, A6 = -1. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 5693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10		- 50 - 55	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25* 26* 27* 28*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44 9.46 0.48	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666 1.53368	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78 55.90 55.90	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.62 0.56
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e 19th surface k = -2.829 A4 = 3.81519e 20th surface k = -0.623 A4 = -2.50444 21th surface	e-06, A6 = 2. e-06, A6 = -1. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 5693e-07	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10		- 50	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25* 26* 27* 28* 29*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44 9.46 0.48 9.92 12.85 7.33	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666 1.53368	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78 55.90	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.62 0.56
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e- 19th surface k = -2.829 A4 = 3.81519e- 20th surface k = -0.623 A4 = -2.50444 21th surface	e-06, A6 = 2. e-06, A6 = -0. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 1.5693e-07 1.91852e-0 3.72162e-	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10 .04792e-0)9	- 50 - 55	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25* 26* 27* 28* 29* 30*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813 70.148 -183.515 -284.510 -28.520 198.897 -40.316 93.660 212.953 25.378 -119.565 52.177 10.383 -44.349 -53.218	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44 9.46 0.48 9.92 12.85 7.33 2.07	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666 1.53368 1.53368	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78 55.90 55.90	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.62 0.56 0.56
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e- 19th surface k = -2.829 A4 = 3.81519e- 20th surface k = -0.623 A4 = -2.50444 21th surface k = -1.166 A4 = 2.08328e-	e-06, A6 = 2. e-06, A6 = -0. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 1.5693e-07 1.91852e-0 3.72162e-	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10 .04792e-0)9	- 50 - 55	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25* 26* 27* 28* 29* 30* 31*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44 9.48 9.92 12.85 7.33 2.07 10.09	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666 1.53368	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78 55.90 55.90	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.62 0.56 0.56
k = 1.432 A4 = -1.17703 16th surface k = -1.632 A4 = -6.09995 17th surface k = 0.162 A4 = -9.42741 18th surface k = 0.151 A4 = 1.94021e- 19th surface k = -2.829 A4 = 3.81519e- 20th surface k = -0.623 A4 = -2.50444 21th surface k = -1.166 A4 = 2.08328e- 22th surface	e-06, A6 = 2. e-06, A6 = -0. -06, A6 = 1.0 -06, A6 = -6.	.72227e-0 1.49326e- 1.5693e-07 1.91852e-0 3.72162e-	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58	00562e-11 00257e-11 21e-10 .04792e-0)9	- 50 - 55	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25* 26* 27* 28* 29* 30*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813 70.148 -183.515 -284.510 -28.520 198.897 -40.316 93.660 212.953 25.378 -119.565 52.177 10.383 -44.349 -53.218	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44 9.46 0.48 9.92 12.85 7.33 2.07	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666 1.53368 1.53368	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78 55.90 55.90	0.53 0.63 0.59 0.53 0.58 0.56 0.53 0.62 0.56 0.56 0.56 0.56
k = 1.432 A4 = -1.17703	e-06, A6 = 2. e-06, A6 = 1.0 -06, A6 = -6. e-06, A6 = -6. -05, A6 = -9.	.72227e-0 1.49326e- 1.5693e-07 1.91852e-0 3.72162e- 1.68055e-0	8, A8 = -7.6 08, A8 = 6.0 , A8 = 8.446 8, A8 = 2.58 08, A8 = -1 8, A8 = -1.1	00562e-11 00257e-11 21e-10 .04792e-0)	- 50 - 55	5* 6* 7* 8* 9* 10* 11* 12* 13 14 15 16(Stop) 17* 18* 19 20 21 22 23* 24* 25* 26* 27* 28* 29* 30* 31* 32*	54.300 -23.738 85.904 -97.520 105.081 -33.023 -38.264 53.734 62.691 -22.596 -112.813	10.00 0.98 4.20 0.06 8.88 0.42 2.80 0.07 11.68 5.75 3.53 -1.56 2.54 0.24 8.92 8.41 17.49 16.34 5.46 16.44 9.46 9.92 12.85 7.33 2.07 10.09 2.00	1.49700 1.63490 1.58364 1.49700 1.72047 1.53368 1.49700 1.72047 1.49700 1.84666 1.53368 1.53368 1.53368	81.61 23.88 30.30 81.61 34.71 55.90 81.61 34.71 81.61 23.78 55.90 55.90 55.90	0.53 0.63 0.59 0.53 0.56 0.56 0.56 0.56 0.56 0.56 0.56 0.56 0.56

A4 = -7.29707e - 06, A6 = -3.93011e - 09, A8 = -1.35076e - 11

A4 = 6.21711e-07, A6 = -2.35958e-09, A8 = -9.91770e-12

26th surface

k = -36.249

-continued	

-continued			-	continue	ed		
Unit mm				Unit mm			
Aspherical Surface data		27th surfac	e				
1st surface	<u> </u>	k = -11.90 $A4 = -5.75$	9 5821e-06, A6 = 3	19672e=0)8 A8 = -4 3	11284e-11	
k = 4.443 A4 = -1.05776e-04, $A6 = -3.64425e-07$, $A8 = 1.98904e-092nd surface$		$\frac{28\text{th surfac}}{28\text{th surfac}}$ $k = -1.033$	e	.190720	70,710 - 1.5		
k = -19.238 A4 = -3.91023e-05, A6 = -3.11804e-08, A8 = -5.67242e-11 3rd surface	10	$A4 = -2.20$ $\underline{29th \ surfac}$ $k = 5.439$	0475e-05, A6 = 7	'.79789e-(08, A8 = 9.56	5535e-11	
k = -20.954 A4 = 2.62599e-06, A6 = 1.82851e-08, A8 = 4.54659e-11 4th surface	15	A4 = -2.60 30th surface $k = 2.910$	0359e-05, A6 = 9 ee	0.13286e=0	08, A8 = 2.72	2747e-12	
k = 9.940 A4 = -1.61900e-05, A6 = 9.03155e-09, A8 = 1.79996e-10		A4 = -1.84 $31 th surfac$ $k = -0.869$.39362e-0	08, A8 = -9.4	12280e-11	
5th surface k = 1.123 A4 = 2.67856e-07, A6 = -3.15865e-08, A8 = 3.49785e-11	20	A4 = 3.334 $32th surface$	460e-05, A6 = -1	.85661e-0	08, A8 = 8.80	359e-11	
6th surface		k = -24.51 A4 = -1.19	9291e-05, A6 = -	-5.06023e-	-10, A8 = -1	.47595e-1	.1
k = -2.027 A4 = 3.50357e-06, A6 = 2.04747e-08, A8 = 6.93297e-11 7th surface	25	NA	,	Various da	ta	0.60	
k = 2.496 A4 = -4.68859e-06, A6 = -7.75345e-09, A8 = 6.02390e-11 8th surface	30	Magn Focal Image fb(mn	ification length height(mm) n) (in air)	المام منسا		-3.51 7.51 20.78 4.00 196.17	
k = 3.339 A4 = 3.50988e-07, A6 = 2.15482e-08, A8 = -2.56013e-11 9th surface		Lens	total length(mm)	xample	69	190.17	
k = 3.604 A4 = 1.20384e-07, A6 = 1.78755e-08, A8 = -3.15317e-13 10th surface	35			Admipie			
k = 0.355				Unit mm			
A4 = 1.24700e-05, A6 = 2.89708e-10, A8 = 3.47525e-11 11th surface	40		\$	Surface dat			
k = 1.839 A4 = 3.37433e-06, A6 = 3.63821e-09, A8 = 5.61429e-11		Surface no. 1*	-29.955	d 5.67	nd 1.85135	vd 40.10	θgf 0.569
12th surface		2* 3* 4*	21.219 26.565 -29.352	0.05 3.07 0.05	1.53368	55.90	0.563
k = -10.495 A4 = -1.54011e-05, A6 = -1.49070e-09, A8 = 3.23097e-11 17th surface	45	5* 6*	27.194 -12.447	4.58 0.05	1.49700	81.61	0.538
k = 0.528		7* 8* 9*	41.662 -59.590 44.366	1.69 0.05 3.67	1.49700 1.63490	81.61 23.88	0.538
A4 = -5.62809e-07, A6 = -5.77511e-09, A8 = -1.61623e-11 18th surface	50	10* 11* 12*	-17.202 -19.670 30.021	0.50 1.21 0.20	1.58364	30.30	0.599
x = -142.321 A4 = 4.44624e-06, A6 = 9.06780e-09, A8 = -3.00760e-11 23th surface		13 14 15	23.366 -12.616 68.194	5.25 0.50 2.31 -1.10	1.49700 1.72047	81.61 34.71	0.538 0.583
k = -1.909 A4 = -9.55582e-07, A6 = -2.84663e-09, A8 = 4.48649e-12 24th surface	55	16(Stop) 17* 18* 19	21.245 -93.246 -148.608	1.85 0.09 2.90	1.53368 1.49700	55.90 81.61	0.563 0.538
k = -158.290 A4 = -2.56151e-06, A6 = -1.96788e-09, A8 = 4.34014e-12		20 21 22 23*	-12.601 37.919 -24.743 34.680	1.24 4.85 6.71 2.10	1.72047 1.49700 1.84666	34.71 81.61 23.78	0.583 0.538 0.620
25th surface	60	24* 25*	92.807 12.166	9.47 7.28	1 53368	55 90	0.563

25* 26* 27*

31*

28* 29* 65 30*

12.166 -40.917

40.697

5.464

69.863

-23.297

-8.406

7.28

0.63

4.65

4.96

4.34

2.44

3.04

1.53368

1.53368

1.53368

1.53368

0.563

0.563

0.563

0.563

55.90

55.90

55.90

55.90

10

15

20

25

30

35

40

45

50

55

60

65

-continued

		Unit mm			
32*	13.145	2.00			
33	∞	0.30	1.51640	65.06	0.535
34	∞	0.95			
Image plane	∞				

Aspherical Surface data

1st	surface
1	2.044

> A4 = -5.95233e - 04, A6 = -2.01185e - 05, A8 = -4.04057e - 082nd surface

k = -26.594

A4 = -2.91563e - 04, A6 = 3.38545e - 08, A8 = -4.48601e - 093rd surface

k = -38.988

A4 = 1.31076e - 05, A6 = 1.39853e - 07, A8 = 7.03094e - 094th surface

k = 7.191

A4 = -8.19846e - 05, A6 = -3.06820e - 07, A8 = 2.47340e - 085th surface

k = 1.384

A4 = 5.08576e - 06, A6 = -7.77373e - 07, A8 = 6.23909e - 096th surface

k = -1.761

A4 = 1.48354e - 05, A6 = 4.86920e - 07, A8 = 6.06003e - 097th surface

k = -14.126

A4 = -5.35357e - 05, A6 = -2.25010e - 07, A8 = 6.88366e - 098th surface

k = -2.133

A4 = 1.05864e - 05, A6 = 6.95122e - 07, A8 = -3.15146e - 099th surface

k = 3.451

A4 = 2.22795e-06, A6 = 4.87778e-07, A8 = -1.66619e-0910th surface

k = 0.360

A4 = 1.03539e-04, A6 = -6.33943e-08, A8 = 4.04592e-0911th surface

k = 1.941

A4 = 2.37787e - 05, A6 = 1.62382e - 07, A8 = 7.66827e - 0912th surface

k = -10.761

A4 = -1.30990e - 04, A6 = -1.71078e - 07, A8 = 5.02262e - 0917th surface

k = -0.267

A4 = -1.00551e - 05, A6 = -2.52136e - 07, A8 = 4.24466e - 1018th surface

k = -207.405

A4 = 2.84376e - 05, A6 = 3.79772e - 07, A8 = -4.21658e - 0923th surface

A4 = -7.10617e - 06, A6 = -8.60971e - 08, A8 = 7.01716e - 1024th surface

k = -186.451

A4 = -2.28317e - 05, A6 = -6.42653e - 08, A8 = 6.74174e - 1025th surface

k = -1.569

A4 = -6.55071e - 05, A6 = -2.05782e - 07, A8 = -4.37955e - 09, A10 = -2.52773e - 14

-continued

Unit mm

26th surface

k = -3.839A4 = -8.01566e - 06, A6 = -2.54791e - 07, A8 = -1.15935e - 09,

A10 = -2.54003e - 1427th surface

k = -34.425

A4 = -4.77157e - 05, A6 = 1.08255e - 06, A8 = -4.06557e - 0928th surface

A4 = -1.54742e - 04, A6 = 2.47821e - 06, A8 = -3.91574e - 09

29th surface

k = -50.008

A4 = -5.21414e - 05, A6 = 4.83615e - 07, A8 = -8.84765e - 09, A10 = 1.50137e - 12

30th surface

k = -29.019

A4 = 1.22863e - 04, A6 = 8.90770e - 07, A8 = -5.28257e - 09,

A10 = 5.46743e - 13

31th surface

k = -0.773

A4 = 3.16385e - 04, A6 = 9.74440e - 08, A8 = 1.40543e - 08, A10 = -5.53413e - 14

32th surface

k = -16.868

A4 = -1.76589e - 04, A6 = 8.02882e - 07, A8 = -7.40507e - 09,

A10 = -1.70931e - 12

Various data	
NA	0.59
Magnification	-3.51
Focal length	3.49
Image height(mm)	10.82
fb(mm) (in air)	3.15
Lens total length(mm) (in air)	87.44

Example 70

Unit mm	
Surface data	

		Surface dat	а		
Surface no.	r	d	nd	νd	$\theta g f$
1*	-51.987	5.12	1.85135	40.10	0.569
2*	34.312	0.50			
3*	36.711	2.87	1.53366	55.96	0.555
4*	-92.469	0.20			
5*	26.612	4.74	1.49700	81.61	0.538
6*	-11.451	0.05			
7*	45.611	2.06	1.49700	81.61	0.538
8*	-54.045	0.20			
9*	33.570	3.44	1.63484	23.91	0.622
10*	-21.835	1.05			
11*	-19.881	0.50	1.58360	30.33	0.591
12*	20.272	0.52			
13	29.888	5.28	1.49700	81.61	0.538
14	-9.919	0.50	1.72047	34.71	0.583
15	2653.840	0.67			
16(Stop)	∞	0.00			
17*	22.326	5.73	1.53366	55.96	0.555
18*	-48.583	0.50			
19	-361.891	3.71	1.49700	81.61	0.538
20	-14.580	0.81	1.72047	34.71	0.583
21	49.171	13.96	1.49700	81.61	0.538
22	-23.109	1.04			

21/				210			
-continued			-0	continue	ed		
Unit mm	_	Unit mm					
* 34.641 3.26 1.84666 23.78 0.621	- 5	24th surface					
\$ 68.766 8.81 \$ 14.872 7.26 1.53366 55.96 0.555 \$ -32.487 0.20 \$ 24.860 4.91 1.53366 55.96 0.555	3	k = 0.000 A4 = -2.71164 25th surface	4e-05, A 6 = -:	5.85984e-	-08, A8 = 5.2	:8978e-10)
5 5.064 10.91 6 -6.358 3.04 1.53366 55.96 0.555 7 -143.898 1.00 7 0.30 1.51633 64.14 0.535	10	k = -1.287 A4 = -5.62805 26th surface	5e-05, A6 = -'	7.66209e-	-08, A8 = -1	.46489e-0	09
∞ 2.00 age plane ∞	_	k = -28.138 A4 = -8.59208	3e-06, A6 = -	1.62519e-	-07, A8 = -5	.25099e-1	10
Aspherical Surface data	– 15	27th surface					
$\frac{1}{\text{st surface}}$ $k = -2.324$	_	k = -11.343 A4 = -9.45284 28th surface	4e-05, A6 = 8.	98312e-0	97, A8 = -3.2	8383e-09)
A4 = -5.99284e-04, A6 = -2.07443e-05, A8 = -5.78774e-08 2nd surface k = -45.725	— 20	k = -1.166 A4 = -2.25428 29th surface	3e-04, A6 = 2.	61901e-0	06, A8 = -9.6	55650e-09)
A4 = -3.42295e-04, A6 = -7.55261e-07, A8 = -1.43674e-08 3rd surface		k = -0.771 A4 = -1.76889 30th surface	9e-04, A6 = 3.	16654e-0	06, A8 = -5.4	3037e-08	3
k = -4.989 A4 = 1.53046e-05, A6 = -3.22204e-07, A8 = 1.52980e-08 4th surface	25	k = 0.000 $A4 = -3.96799$	9e-04, A6 = 8.	52970e=0	07, A8 = -2.3	7397e-09)
k = 10.000	-		V	arious dat	ta		
A4 = -1.19884e-04, A6 = 7.20040e-07, A8 = 1.57561e-08 5th surface k = 2.681 A4 = 5.72765e-06, A6 = -6.11721e-07, A8 = 7.66294e-09 6th surface	— 30					0.62 -3.55 3.98 11.04 3.20	
k = -2.065 A4 = 2.37171e-05, A6 = 6.14576e-07, A8 = 9.37247e-09 7th surface k = 8.756	35		Ex	kample '	71		
A4 = -2.94464e-05, A6 = -1.23697e-07, A8 = 8.83931e-09 8th surface	40 -			** **			
k = -18.390	-			Unit mm			
A4 = 1.93047e-05, A6 = 8.03884e-07, A8 = -2.96453e-09 9th surface	-		S	urface dat	a		
-		Surface no.	r	d	nd	νd	θgf
k = 4.712 A4 = 2.70731e-07, A6 = 5.42517e-07, A8 = -1.96572e-10 10th surface	45 —	1* 2* 3*	-33.708 30.549 32.705	5.42 0.05 3.04	1.85135 1.53366	40.10 55.96	0.569 0.555
k = 0.590 A4 = 9.35359e-05, A6 = 8.42783e-08, A8 = 1.48700e-09 11th surface	50	4* 5* 6* 7*	-33.718 30.277 -9.108 30.171	0.05 5.37 1.92 4.74	1.49700 1.63484	81.61 23.91	0.538 0.622
k = 1.834 A4 = 2.94251e-05, A6 = -5.71155e-08, A8 = 8.02874e-09	_ 30	8* 9* 10*	-20.083 -21.758 20.217	0.50 0.50 0.31	1.58360	30.33	0.591
12th surface k = -8.347		11 12 13 14(Stop)	22.752 -11.085 109.760 ∞	5.35 0.50 1.33 -1.02	1.49700 1.72047	81.61 34.71	0.538 0.583
A4 = -9.71672e-05, A6 = 9.03846e-09, A8 = 5.98733e-09 17th surface	_	15* 16* 17	19.480 -36.243 -46.615	3.80 0.50 2.73	1.53366 1.49700	55.96 81.61	0.555 0.538
k = -0.493 A4 = -1.13272e-05, A6 = -1.77520e-07, A8 = 1.69868e-09 18th surface	60	18 19 20	-13.271 63.152 -21.328	1.29 10.17 5.57	1.72047 1.49700	34.71 81.61	0.583 0.538
k = 0.000 A4 = 4.90449e-05, A6 = 8.80405e-08, A8 = 2.05302e-12		21* 22* 23*	33.223 62.274 13.399	2.86 10.12 6.98	1.84666 1.53366	23.78 55.96	0.621 0.555
$\frac{23\text{th surface}}{k = -0.340}$	65	24* 25* 26*	-44.297 23.820 5.404	0.10 4.79 10.39	1.53366	55.96	0.555
A4 = -4.99251e - 06, $A6 = -1.15596e - 07$, $A8 = 5.65807e - 10$		27*	-5.660	2.59	1.53366	55.96	0.555

-1/
continued

219	220
ontinued	-continued

		Unit mm			
28* 29 30 Image plane	-57.346	1.00 0.30 1.99	1.51633	64.14	0.535 5
	Aspher	ical Surfa	ce data		
1st surface					10
k = -2.324 A4 = -5.992846 2nd surface	e-04, A6 = -2	2.07443e-	-05, A8 = -5	.78774e-0	08
k = -8.453 A4 = -3.062186 3rd surface	e-04, A6 = -6	5.21190e-	-07, A8 = -3	.79375e-(15 09
k = -10.000 A4 = -2.322376 4th surface	e-05, A6 = -4	1.72804e-	-07, A 8 = 1.2	1769e-08	3 20
k = 9.824 A4 = -9.509296 5th surface	e-05, A6 = 4.	21290e-0	97, A8 = 1.39	565e-08	
k = 0.977 A4 = -1.410546 6th surface	e-06, A6 = -1	7.40956e-	-07, A8 = 9.0	5571e-09	25
k = -1.674 A4 = -1.619926 7th surface	e-06, A6 = 3.	89543e-(97, A8 = 9.27	075e-09	30
k = 4.822 A4 = -3.063296 8th surface	e-06, A6 = 5.	40103e-0	97, A8 = 3.70	020e-10	
k = 0.187 A4 = 1.04929e- 9th surface	-04, A6 = 2.3	5490e-07	', A8 = 2.619	93e-09	35
k = 1.884 A4 = 1.43703e- 10th surface	-05, A6 = -1.	78034e-0	97, A8 = 9.88	090e-09	40
k = -9.975 A4 = -1.061126 15th surface	e-04, A6 = 2.	10535e-0	97, A8 = 3.08	727e-09	
k = -0.105 A4 = -1.013086 16th surface	e-05, A6 = -9	9.94355e-	-08, A8 = 2.4	.6319e-09	45
k = -9.295 A4 = 5.21616e- 21th surface	-05, A6 = 2.6	7714e-07	, A8 = 8.322	27e-10	50
k = -0.825 A4 = -4.717386 22th surface	e-06, A 6 = -1	1.19133e-	-07, A 8 = 6.3	3286e-10)
k = -9.836 A4 = -2.629756 23th surface	e-05, A 6 = -4	1.49742e-	-08, A8 = 5.5	0 344e –10	55
k = -1.187 A4 = -5.593936 24th surface	e-05, A6 = -2	2.19981e-	-07, A8 = -1	.27378e-0)9 60
k = -9.425 A4 = -3.475900 25th surface	e-06, A6 = -2	2.14126e-	-07, A8 = -4	.68874e-1	.0
k = -10.000 A4 = -9.665696	e-05, A6 = 9.	71367e-0	97, A8 = -4.2	6857e-09	65

Unit mm	
26th surface	
k = -1.038 A4 = -1.80783e-04, A6 = 9.34922e-07, A8 27th surface	= -2.73424e-09
k = -0.796 A4 = 2.33856e-05, A6 = 1.10760e-06, A8 = 28th surface	-4.51672e-08
k = 0.564 A4 = -3.12661e-04, A6 = 2.54558e-07, A8	= -1.58646e-09
Various data	
NA	0.60
Magnification	-3.53
Focal length	3.86
Image height(mm)	11.04
fb(mm) (in air)	3.18
	0120

Example 72

		Unit mm			
	1	Surface dat	a		
Surface no.	r	d	nd	vd	θgf
1*	-36.181	28.58	1.53368	55.90	0.563
2*	-56.946	0.76			
3*	61.405	21.75	1.63490	23.88	0.630
4*	-75.609	1.28			
5*	31.784	13.63	1.49700	81.61	0.538
6*	-109.442	0.05			
7	-131.758	11.91	1.61800	63.33	0.544
8	-32.872	1.02	1.72047	34.71	0.583
9	118.946	2.88			
10(Stop)	∞	4.53			
11	-75.872	1.04	1.72047	34.71	0.583
12	62.232	13.45	1.61800	63.33	0.544
13	-92.209	2.29			
14*	55.068	22.12	1.49700	81.61	0.538
15*	-67.262	34.05			
16*	-33.410	0.69	1.58364	30.30	0.599
17*	-66.553	65.37			
18*	-110.319	24.35	1.63490	23.88	0.630
19*	-70.789	9.27			
20*	28.392	16.92	1.53368	55.90	0.563
21*	-885.222	0.49			
22*	189.555	21.44	1.53368	55.90	0.563
23*	11.316	18.40			
24	∞	0.30	1.51640	65.06	0.535
25	∞	0.07			
Image plane	&				

Aspherical surface data	
1st surface	
k = -173.796 A4 = -3.35526e-04, A6 = 1.26109e-05, A8 = -3.73711e-07 2nd surface	
k = 5.924 A4 = -1.68456e-05, A6 = 1.61406e-08, A8 = -3.13890e-11 3rd surface	
k = -0.972 A4 = -6.35538e-07, A6 = 1.17469e-09, A8 = -2.12993e-13	-

-continued	

th gurfage								
th surface		5			Unit mm			
x = -7.795 A4 = 6.08950e-07, A6 = 2.28598e-09, A8 =	- 1154120 12				Surface dat	a		
th surface	= -1.13413e-12		Surface no.	r	d	nd	νd	θg
x = -2.835		10	1* 2*	-40.282 463.655	4.79 0.15	1.58364	30.30	0.59
A4 = -1.32987e - 06, $A6 = -7.65103e - 10$, A ith surface	8 = -7.52953e-14		3* 4*	-56.383 -22.798	3.04 0.05	1.53368	55.90	0.56
$\zeta = 6.750$			5* 6*	52.768 -30.496	3.31 0.05	1.53368	55.90	0.56
A4 = -1.65736e-06, A6 = -2.85490e-10, A 4th surface	8 = 1.21681e-12	15	7* 8*	99.502 -15.870	4.30 0.05	1.53368	55.90	0.56
			9* 10*	55.361 -40.687	2.56 0.05	1.53368	55.90	0.56
x = -0.859 A4 = -1.10335e-06, A6 = -2.25718e-10, A	8 = 1.30529e-13		11* 12*	-41.002 -132.635	0.70 0.05	1.58364	30.30	0.59
5th surface			13* 14*	-197.895 -19.020	2.52 0.05	1.63490	23.88	0.63
z = 0.165 A4 = 3.95032e-08, A6 = -6.71393e-10, A8	= 2.80361e=13		15* 16*	-24.922 37.592	0.70 0.05	1.58364	30.30	0.59
6th surface	- 2.00301c 13		17 18	32.596 -15.766	6.26 0.70	1.49700 1.72047	81.61 34.71	0.53 0.58
x = -0.459		25	19 20(Stop)	-483.885 ∞	0.05 -0.00			
A4 = 4.57377e-06, A6 = -3.03724e-09, A8 7th surface	= 9.29938e-13	23	21* 22*	31.326 336.567	1.93 0.43	1.53368	55.90	0.56
			23 24	129.510 -16.383	5.53 0.69	1.49700 1.72047	81.61 34.71	0.53 0.58
x = -4.247 A4 = 5.69051e-06, A6 = -4.82179e-09, A8	= 1.67011e-12		25 26	44.942 -28.775	5.29 10.44	1.49700	81.61	0.53
8th surface		30	27* 28*	43.477 108.100	3.20 8.65	1.84666	23.78	0.62
x = -63.971			29* 30*	13.858 -48.612	7.47 1.07	1.53368	55.90	0.56
A4 = 1.34636e-06, A6 = -3.87038e-09, A8 A10 = 1.77701e-15	= -3.48009e-13,		31* 32*	26.460 4.837	6.21 7.57	1.53368	55.90	0.56
9th surface		35	33* 34*	-354.887 -13.673	1.05 1.18	1.53368	55.90	0.56
x = -1.377 A4 = -6.47891e-07, A6 = 1.15104e-10, A8	1.46000 - 12		35* 36*	-10.332 10.221	1.47 2.00	1.53368	55.90	0.56
A10 = 1.56999e–15	= -1.409996-12,		37 38	& &	0.30 1.07	1.51640	65.06	0.53
Oth surface		40	Image plane	∞				
x = -1.324 A4 = -3.27595e-06, A6 = 5.51173e-09, A8	- 0.45068a 13		Aspherical surface data					
A10 = 5.26132e-15	= -9. 4 3008C-13,		1st surface	;				
		45		0276e-04, A6 = -	-1.07790e-	-05, A8 = -1	.87287e-0	08
x = -1.000 A4 = 5.09843e-07, A6 = -7.59988e-10, A8	= -3.15984e-12		2nd surfac	e				
22th surface			k = 7.798 A4 = -2.75758e-04, A6 = 2.10308e-08, A8 = -1.33321e-08					3
x = -1.000 A4 = -1.12247e-06, A6 = -1.43359e-09, A	8 = _6 54554a_12	50	3rd surface					
144 = -1.12247e-00, A0 = -1.43339e-09, P	30.3733 70- 12		k = -18.91 $A4 = -2.56$ $4th surface$	6423e-05, A6 = 8	8.98086e-0	08, A8 = -7.5	50836e-10)
z = -0.877	_ 577450= 10			•				
A4 = -2.88824e-05, A6 = 1.68813e-07, A8 A10 = 7.15614e-12	= -3.774326-10,			7703e-05, A6 = 6	5.34630e-0	99, A8 = 1.59	9473e-10	
Various data			k = 2.825					
NA Maria di	0.81	60	A4 = 4.350 6th surface	005e-06, A6 = -3	3.43208e=0	07, A8 = 1.63	8947e-09	
Magnification Focal length	-3.56 23.68		k = -1.000)				
Image height(mm)	7.93		A4 = -2.56	6460e - 06, A6 = 2	2.06882e=0	98, A8 = 5.97	7876e-10	
tb(mm) (in air) Lens total length(mm) (in air)	18.67 316.53	_						
Image height(mm) fb(mm) (in air)	7.93 18.67	65	k = -1.000 $A4 = -2.50$ 7 th surface $k = -1.000$	6460e-06, A6 = 2				

-continued		

Unit mm	_
8th surface	- - 5
k = -1.945 A4 = 3.71988e-06, A6 = -6.66431e-08, A8 = 2.51358e-09 9th surface	_
$\begin{array}{l} k = -18.446 \\ A4 = -4.05634 \\ e^{-05}, A6 = -2.46856 \\ e^{-07}, A8 = 2.65735 \\ e^{-09} \\ \underline{10} \\ th \ surface \end{array}$	10
k = -1.000 A4 = 1.06948e-06, A6 = 9.57333e-09, A8 = 3.53159e-11 11th surface	_
k = -1.000 A4 = 9.00548e-08, A6 = 1.08965e-08, A8 = 2.56428e-11 12th surface	15
k = -25.185 A4 = 1.20782e-05, A6 = 3.66535e-07, A8 = -1.92641e-09 13th surface	20
$\begin{array}{l} k = 9.934 \\ A4 = -5.58480e{-06}, A6 = 3.40383e{-07}, A8 = -7.89811e{-10} \\ \underline{14} th \ surface \end{array}$	_
$\begin{array}{l} k = 0.011 \\ A4 = 6.84867e{-}05, A6 = 2.15623e{-}08, A8 = 3.28107e{-}09 \\ 15 th \ surface \end{array}$	25
k = 2.072 A4 = 1.58083e-05, A6 = 1.06906e-07, A8 = 3.45403e-09 16th surface	30
k = -5.656 A4 = -8.90526e-05, A6 = -2.43611e-07, A8 = 1.71510e-09 21th surface	_
k = 0.012 A4 = -4.60350e-06, A6 = -1.00301e-07, A8 = 1.22359e-09 22th surface	35
k = -1157.205 A4 = 2.04437e-05, A6 = 1.78478e-07, A8 = 1.96410e-10 27th surface	_ 40
k = 0.320 A4 = -1.89280e-06, A6 = -5.83570e-08, A8 = 1.95523e-10 28th surface	_
$\label{eq:kappa} \begin{split} k &= -177.199 \\ A4 &= -1.76597 e{-05}, A6 = -2.74436 e{-08}, A8 = 1.63913 e{-10} \\ 29th surface \end{split}$	45 _
k = -1.424 A4 = -4.44964e-05, $A6 = -1.14731e-07$, $A8 = -1.32031e-0930th surface$	_ 50
$\begin{array}{l} k = -49.536 \\ A4 = -3.58778 \\ e^{-06}, A6 = -1.51652 \\ e^{-07}, A8 = -4.21497 \\ e^{-10} \\ 31 \\ th \ surface \end{array}$	_
k = -11.097 A4 = -4.01806e-05, A6 = 5.78536e-07, A8 = -3.83048e-09 32th surface	55
k = -1.067 A4 = -5.14012e-05, A6 = 3.96589e-06, A8 = 5.12675e-10 33th surface	– 60
k = -84.746 A4 = -9.39725e-05, A6 = 2.40683e-06, A8 = 1.83664e-08 34th surface	_
k = -19.376 A4 = 3.43366e-04, A6 = 1.79039e-06, A8 = -6.69090e-09	65

.. .

	-	continue	d		
		Unit mm			
35th surface	÷				
k = -5.308 A4 = 2.7588 36th surface	81e-04, A6 = 2.5	51333e-07	, A8 = 1.186	69e-08	
k = -14.558 $A4 = -1.726$	3 642e-04, A6 = 1	29748e –0	6, A8 = -2.4	9913e-08	3
	,	Various dat	a		
Foca Ima fb(n	gnification al length ge height(mm) um) (in air) s total length(mr	n) (in air) xample ^	74	0.80 -3.54 3.60 7.39 3.27 94.87	
		Unit mm			
		Surface dat	a		
Surface no.	r	d	nd	νd	θgf
1* 2*	-22.220 -110.607	11.55 0.80	1.53368	55.90	0.563
3*	69.374	9.96	1.84666	23.77	0.620

		Juliace dat	·u		
Surface no.	r	d	nd	vd	$\theta g f$
1*	-22.220	11.55	1.53368	55.90	0.563
2*	-110.607	0.80			
3*	69.374	9.96	1.84666	23.77	0.620
4*	-55.648	11.12			
5*	-53.462	3.04	1.58364	30.30	0.599
6*	-1333.696	0.30			
7*	41.975	11.11	1.49700	81.61	0.538
8*	-33.586	6.66			
9	-93.239	5.38	1.61800	63.33	0.544
10	-21.843	1.00	1.72047	34.71	0.583
11	39.981	13.59			
12(Stop)	∞	1.53			
13	-61.889	1.00	1.72047	34.71	0.583
14	50.762	5.24	1.61800	63.33	0.544
15	-54.934	0.10			
16*	59.467	7.14	1.49700	81.61	0.538
17*	-66.460	0.10			
18*	82.096	7.55	1.49700	81.61	0.538
19*	-54.564	3.09			
20*	-64.204	3.00	1.58364	30.30	0.599
21*	444.592	8.67			
22*	71.214	10.98	1.63490	23.88	0.630
23*	-83.225	28.34			
24*	-67.867	6.01	1.53368	55.90	0.563
25*	-608.925	5.07			
26*	-29.940	1.00	1.53368	55.90	0.563
27*	92.925	5.00			
28	œ	0.30	1.51640	65.06	0.535
29	œ	6.50			
Image plane	∞				

Aspherical	curfoca	data

1st surface
k = -3.559
A4 = 7.43178e-07, A6 = 9.21714e-09, A8 = 5.34633e-12
2nd surface
1 50.705
k = -56.705 A4 = 1.26171e-05, A6 = -2.11058e-08, A8 = 1.11767e-11
3rd surface
1 000
k = -0.891 A4 = -4.74513e - 07, $A6 = -1.03632e - 10$, $A8 = 4.27759e - 13$
A4 = -4.74313e-07, A0 = -1.03032e-10, A6 = 4.27739e-13

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-continued

Unit mm				Unit mm			
4th surface			7	Various da	ta		
k = -2.005 A4 = -2.95949e-07, A6 = 1.71592e-09, A8 = -1.02814e-12 5th surface	5 	Fo	A agnification cal length age height(mm)			0.23 -1.33 23.92 21.63	
k = 0.000 A4 = 1.12076e-06, A6 = -3.15698e-09, A8 = -9.10021e-12 6th surface	10	fb((mm) (in air) ns total length(mm)	(in air)		11.70 175.01	
k = 0.000 A4 = -1.68052e-06, A6 = -2.21792e-10, A8 = -7.11388e-12 7th surface			E	xample	75		
k = -2.402 A4 = -2.97163e-07, A6 = -2.14703e-09, A8 = 5.48901e-12 8th surface	15			TT '			
k = -3.764 A4 = -7.20305e-07, A6 = -1.04316e-09, A8 = 3.58089e-12	20		\$	Unit mm Surface dat			
16th surface		Surface no.	r	d	nd	νd	θgf
k = -0.278 A4 = 9.99889e-07, A6 = -1.23318e-09, A8 = -5.26020e-13 17th surface		1* 2*	-18.167 -6801.076	3.69 0.08	1.53368	55.90	0.56
k = -0.949 A4 = 6.09329e-08, A6 = -2.45917e-10, A8 = 8.84736e-16	25	3* 4* 5* 6*	21.678 -284.362 12.760	6.12 0.36 5.89	1.84666 1.49700	23.77 81.61	0.62
18th surface k = 3.430	_	7 8 9	-83.302 -13.598 -8.480 110.487	2.65 1.64 0.70 4.96	1.59522 1.72047	67.74 34.71	0.54 0.58
A4 = 2.90794e-08, A6 = 5.65189e-10, A8 = -6.39630e-16 19th surface	30	10(Stop) 11 12	∞ -48.292 19.168	0.80 0.70 3.57	1.72047 1.61800	34.71 63.33	0.58 0.54
k = -2.160 A4 = -3.62571e-07, A6 = -3.42492e-09, A8 = -3.01979e-13 20th surface		13 14* 15*	-22.873 28.235 -20.667	0.05 4.20 0.05	1.49700	81.61	0.53
k = -0.380 A4 = 9.15647e-07, A6 = -7.30470e-09, A8 = -7.03078e-13 21th surface	35	16* 17* 18* 19*	30.523 -26.992 -43.570 28.439	4.86 2.22 1.92 3.33	1.49700 1.58364	81.61 30.30	0.53
k = 0.000 A4 = 1.54086e-06, A6 = 1.31932e-09, A8 = 6.29723e-16	40	20* 21* 22*	37.236 -37.308 -11.417	3.81 12.91 0.70	1.63490 1.53368	23.88 55.90	0.63 0.56
22th surface k = -8.393	_	23* 24* 25* 26	-54.620 -15.141 52.853 ∞	3.52 1.00 1.42 0.30	1.53368 1.51640	55.90 65.06	0.56
A4 = 1.48279e-07, A6 = 1.47956e-10, A8 = 2.41697e-13, A10 = -4.40436e-16 23th surface	45	27 Image plane	∞	0.50	1.31040	03.00	0.55
k = 0.000			Asphe	rical surfa	ce data		
A4 = -1.31114e-06, A6 = 1.09844e-09, A8 = -5.20796e-13, A10 = 1.48100e-16 24th surface			$\frac{1st surface}{k = -4.386}$				
k = -2.311 A4 = -2.41567e-05, A6 = 2.27044e-08, A8 = -4.28423e-11,	50		A4 = 8.13964e-05 2nd surface	5			
A10 = -3.47983e-14 25th surface			k = -48.345 A4 = -1.43933e - 0 3rd surface	04, A6 = -	8.00000e-08	3	
k = 0.000 A4 = -4.10895e-06, A6 = -3.67106e-09, A8 = -4.04819e-11, A10 = -2.16188e-17 26th surface			k = -0.148 A4 = 2.62435e-05 4th surface	5, A6 = 7.4	16587e-08		
k = 0.000 A4 = -1.11631e-06, A6 = 8.03468e-09, A8 = -1.08760e-11, A10 = 2.40056e-17	60		k = -2.471 A4 = 1.13156e-04 5th surface	4, A6 = -3	.03432e-07		
27th surface k = -33.623 A4 = -2.66905e-05, A6 = 4.78713e-08, A8 = -7.55486e-11,			k = 0.000 $A4 = -3.28501e^{-0}$ 6th surface	05			
A10 = 4.72095e-14	65		k = 0.000 A4 = 1.86975e-04	4, A6 = 1.1	.8474e-06		

0.544

0.583

0.583

0.544

0.538

0.538

0.599

0.630

0.563

0.563

0.535

continued		
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Unit mm					Unit mm			
14th surface		5	8*	-10.668	1.93			
		3	9	-37.991	1.88	1.61800	63.33	
k = -0.451			10	-6.858	0.70	1.72047	34.71	
A4 = -7.69062e - 06, $A6 = -1.43734$	e-08		11	12.533	3.26			
15th surface			12 (Stop)	œ	0.31			
			13	-25.651	0.70	1.72047	34.71	
k = -1.249			14	12.946	2.21	1.61800	63.33	
A4 = 2.02493e-05, A6 = 4.19132e-0	ng	10	15	-21.372	0.05	1.01000	05.55	
16th surface			16*	25.619	3.07	1.49700	81.61	
10th surface			17*	-16.426	0.05	1.42700	01.01	
1- 0.000						1 40700	01.61	
k = 0.000	0.0		18*	23.987	3.45	1.49700	81.61	
A4 = -8.45589e - 06, $A6 = 8.20795e - 6$	-08		19*	-18.969	0.05			
17th surface			20*	-67.273	1.10	1.58364	30.30	
		15	21*	23.516	0.82			
k = -1.911			22*	23.296	3.10	1.63490	23.88	
A4 = -3.58629e - 05, $A6 = 5.27389e - 05$	-08		23*	-29.511	11.11			
18th surface			24*	-16.767	0.50	1.53368	55.90	
			25*	-22.808	1.74	1,00000		
k = -0.212						1 52260	55.00	
A4 = -6.84952e - 05, $A6 = -5.77815$	e-08	20	26*	-7.454	0.50	1.53368	55.90	
19th surface		20	27*	39.382	2.00			
			28	œ	0.40	1.51640	65.06	
k = 0.000			29	œ	2.09			
A4 = -4.80004e - 05, A6 = -6.13427	e_08		Image plane	œ				
A4 = -4.80004e - 05, A0 = -0.13427 20th surface	6-08	-	<i>U</i> 1					_
				Aspher	rical surfa	ce data		
k = -6.911		25 _						_
A4 = 3.04669e - 05, $A6 = -1.68754e$	-07		1st surface					_
21th surface								
			k = -3.337					
k = 0.000			A4 = 7.81336e	-05, A6 = 7.2	6382e-07	', A8 = 2.768	89e-08	
A4 = 1.99883e - 06, $A6 = -1.14266e$	-08		2nd surface					
22th surface		30						_
			k = -12.283					
k = 0.000			A4 = 1.65761e	-04, $A6 = -4$.	78004e-0	6. A8 = 1.77	7405e-08	
A4 = -3.55672e - 05, $A6 = 1.28738e - 05$	-06		3rd surface	<i>'</i>		,		
23th surface								_
1- 0.000			k = -0.001					
k = 0.000		35	A4 = 2.82582e	-06 A6 = 64	0852e=09	A8 = 4337	50e-09	
A4 = 7.71680e - 05			4th surface	00,210 0.1	00020 07	,210 11337	300 03	
24th surface			-ui sui iace					_
k = 0.000			k = -3.772					
	07		A4 = 3.75820e	-05 A6 - 3 8	13256_07	A8 = -1 37	7171e_00	
A4 = 1.41483e - 04, A6 = 1.00000e - 0	01			00,210 - 0.6	10200-07	, 2101.57	1/10-09	
25th surface		40	5th surface					_
k = -200.000			k = 0.000					
A4 = -1.00622e - 04, $A6 = -2.32970$	e-07		A4 = 7.52926e	_05_A6 = _1	785786_0	6 A8 = -1 3	866860_08	
	• •,		6th surface	-03, A0 = -1.	103100-0	70, A6 = -1	70000 C =00	
Various data			our surface					_
		45	k = 0.000					
NA	0.23	43	A4 = -5.68162	e-05, $A6 = -5$	5.39505e-	-07, $A8 = -3$.46650e-0)
	Magnification -1.33		7th surface	*		*		
Focal length	8.65							_
Image height(mm)	Image height(mm) 10.82		lr 2.416					
fb(mm) (in air)			k = -2.416					
Lens total length(mm) (in air)	71.86		A4 = -3.38395	e-05, A6 = -1	3.57963e-	-0.7, A8 = 2.5	9868e-08	•
		50	8th surface					
			1- 4.029					
			k = -4.028	05.45.55	2002 6-		22 00	
Example 76			A4 = 2.66890e	-05, A6 = 7.3	2902e-07	, A8 = 2.650	123e-08	
-			16th surface					_
			l 0.010					
		55	k = -0.019					

		Unit mm				_
	S	urface da	ta			_
Surface no.	r	d	nd	νd	$\theta g f$	6
1*	-6.594	2.71	1.53368	55.90	0.563	-
2* 3*	-15.141 22.089	0.05 3.91	1.84666	23.77	0.620	
4* 5*	-18.712 -17.254	2.70 1.10	1.58364	30.30	0.599	
6* 7*	34.657 12.140	0.11 3.83	1.49700	81.61	0.538	6

 $\begin{array}{l} k = -0.019 \\ A4 = 8.97367e - 05, A6 = -1.03233e - 06, A8 = 7.72299e - 09 \end{array}$ 17th surface

k = -1.855A4 = 1.90242e-05, A6 = -6.72839e-07 18th surface A4 = 9.30171e-06, A6 = 3.12746e-0719th surface

k = -1.268

A4 = -1.75825e - 05, A6 = -1.24240e - 07, A8 = 6.25523e - 09

20th surface	 5
k = 0.000 A4 = -2.42353e-06, A6 = -2.15990e-06, A8 = 7.78426e-09 21th surface	
k = 0.000 A4 = 2.55273e-05, A6 = -1.61257e-08 22th surface	10
k = -7.622 A4 = -3.41674c-06, A6 = -3.51619e-08, A8 = 5.04095e-09, A10 = -4.72437e-11 23th surface	1:
k = 0.000 A4 = -8.30630e-05, A6 = 3.95126e-08, A8 = 3.41864e-09, A10 = -2.19047e-11 24th surface	
k = 0.000 A4 = -6.73311e-04, A6 = 3.53688e-06, A8 = 6.26103e-08, A10 = -2.83370e-09 25th surface	20
k = -31.496 A4 = -2.03990e-04, A6 = -1.56737e-06, A8 = -7.81513e-08 26th surface	2:
k = 0.000 A4 = 4.15201e-04, A6 = -1.51111e-06, A8 = 1.73325e-09 27th surface	30
k = -182.577 A4 = -7.13102e-04, A6 = 1.05027e-05, A8 = -1.26316e-07, A10 = -4.92836e-11	
Various data	_
	— 3:

Various data		
NA	0.23	35
Magnification	-1.34	
Focal length	7.83	
Image height(mm)	7.46	
fb(mm) (in air)	4.36	
Lens total length(mm) (in air)	55.30	40

Example 77

		Unit mm			
	:	Surface da	ta		
Surface no.	r	d	nd	\mathbf{v} d	$\theta g f$
1*	-5.961	2.31	1.53368	55.90	0.563
2*	-24.609	0.05			
3*	17.837	2.80	1.84666	23.77	0.620
4*	-14.424	1.82			
5*	-15.035	0.46	1.58364	30.30	0.599
6 *	3512.460	0.05			
7*	9.702	3.32	1.49700	81.61	0.538
8*	-7.673	0.99			
9	-31.622	1.50	1.61800	63.33	0.544
10	-5.784	0.70	1.72047	34.71	0.583
11	9.829	3.18			
12 (Stop)	∞	0.25			
13	-19.695	0.70	1.72047	34.71	0.583
14	12.012	1.60	1.61800	63.33	0.544
15	-12.780	0.05			
16*	18.475	2.02	1.49700	81.61	0.538
17*	-13.500	0.05			
18*	11.482	2.43	1.49700	81.61	0.538
19*	-27.656	0.49			

-continued

		-	commue	÷u		
			Unit mm			
20*		-13.626	0.52	1.58364	30.30	0.599
21* 22*		-361.234 16.895	1.85 1.87	1.63490	23.88	0.630
23* 24* 25*		-23.260 -7.198 -10.330	5.30 0.46 1.16	1.53368	55.90	0.563
26* 27*		-5.492 18.144	0.50 2.00	1.53368	55.90	0.563
28 29		∞ ∞	0.30 0.81	1.51640	65.06	0.535
Ima	ge plane	∞				
		Asphe	rical surfa	ce data		
	1st surface					
	k = -3.978 A4 = 6.83164 2nd surface	le-05, A6 = 1.9	94032e-05	, A8 = 1.334	54e-07	
	k = -58.626 A4 = 7.53903 3rd surface	8e-04, A6 = -2	.26638e-0	05, A8 = 1.17	000e-07	
	k = -1.266 A4 = -2.7750 4th surface	00e-05, A6 = 6	.78520e-0	97, A8 = 4.37	879e-09	
	k = -3.007 A4 = 1.25194 5th surface	4e-05, A6 = 2.2	27427e-06	5, A8 = 9.949	44e –10	
	k = 0.000 A4 = 1.27950 6th surface)e-04, A6 = -1	.46201e-0	06, A8 = -1.0	5504e-07	
	k = 0.000 A4 = -1.1448 7th surface	31e-04, A6 = -	3.81661e-	-07, A 8 = -1.	.23805e-0	17
	k = -1.950 $A4 = -9.7217$ 8th surface	73e-06, A6 = -	4.81006e-	-06, A8 = 1.4	.6505e-07	
	k = -4.052 A4 = 1.27783 16th surface	Be-05, A6 = 1.1	.7082e-06	5, A8 = 9.416	36e-08	
	k = -2.587 $A4 = 7.94127$ 17th surface	/e-05, A6 = 2.3	33251e-09	9, A8 = -2.69	891e-08	
	k = 0.444 A4 = -2.3623 18th surface	39e-05, A6 = 3	.53777e-0	07		
	k = 0.000 A4 = 2.69183 19th surface	8e-05, A6 = 7.4	12095e-07	r		
			12095e-07	06 48 - 0	15927- 1	0

A4 = -7.15117e-05, A6 = -3.49750e-06, A8 = -9.15827e-10 20th surface

A4 = 8.37580e-05, A6 = -8.92246e-06, A8 = 7.34778e-08

A4 = 2.70247e - 05, A6 = 7.50428e - 07, A8 = -7.24965e - 08,

A4 = 5.59543e - 05, A6 = -9.82470e - 07

 $\frac{21\text{th surface}}{k = 0.000}$

 $\frac{22\text{th surface}}{k = -9.050}$

A10 = 1.48867e - 10

	-(continue	ed				-continued			
		Unit mm					Unit mm			
23th surface	•					 - 5	Aspherical surface data			
k = 0.000						_	1st surface			
A4 = -3.000 $A10 = -4.67$ $24th surface$		9.41421e-	-07, A8 = -1	.23680e-(08,	_	k = -3.753 A4 = 1.53644e-04, A6 = 3.51095e-05, A8 = 3.76371e-07 2nd surface			
k = -0.035 A4 = -1.976 A10 = -1.49 25th surface		.98966e-0)5, A8 = -7.4	4586e-07	7,	10	k = -52.983 A4 = 1.19282e-03, A6 = -4.36922e-05, A8 = 4.49809e-07 3rd surface			
k = 0.000 A4 = 3.4723 26th surface	30e-05, A6 = -6	.91721e-0	06, A8 = -6.5	7343e-08	8	15	k = -1.023 A4 = -4.33927e-05, A6 = 1.26681e-06, A8 = 1.69670e-08 4th surface			
k = 0.000 A4 = 3.6283 27th surface	36e-06, A 6 = 9.6	52479e-06	5, A8 = -6.05	415e-07		_	k = -2.862 A4 = 8.92430e-06, A6 = 4.43110e-06, A8 = -2.90479e-08 5th surface			
k = -77.408 $A4 = -1.881$ $A10 = 1.101$	100e-03, A6 = 3	.52845e-(05, A8 = -1.4	8363e-06	5,	20	k = 0.000 A4 = 1.82796e-04, A6 = -3.80553e-06, A8 = -3.13184e-07 6th surface			
	7	/arious dat	ta			_	k = 0.000			
NA				0.22		- 25	A4 = -1.74059e-04, $A6 = -1.12245e-06$, $A8 = -3.34962e-077th surface$			
Mag Foca	Magnification -1.34 Focal length 5.46						k = -2.012			
fb (n	ge height (mm) nm) (in air) s total length (mr	n) (in air)		5.33 3.01 39.44			A4 = 1.52723e-05, A6 = -8.41101e-06, A8 = 3.66174e-07 8th surface			
						_ 30	k = -3.986 A4 = 8.69409e-06, A6 = 1.21957e-06, A8 = 2.32185e-07 16th surface			
	-									
	Ez	xample	78			35	k = -1.895 A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface			
	E2					35 -	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030			
		Vample Unit mm				35	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface			
ourface no.		Unit mm		vd	θgf	35 - - - 40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06			
1*	S	Unit mm Surface dat	ta	vd 55.90	θgf 0.563	- -	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000			
1* 2*	r -5.094 -21.978	Unit mm Surface dat d 2.25 0.05	nd 1.53368	55.90	0.563	- -	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665			
1* 2* 3*	s r -5.094	Unit mm Surface dat d 2.25	ta nd			- - - 40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07			
1* 2* 3* 4* 5*	r -5.094 -21.978 14.759 -12.484 -12.647	Unit mm Surface dat d 2.25 0.05 2.61 1.35 0.50	nd 1.53368	55.90	0.563	- -	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface			
1* 2* 3* 4* 5* 6*	-5.094 -21.978 14.759 -12.484 -12.647 -300.282	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05	nd 1.53368 1.84666 1.58364	55.90 23.77 30.30	0.563 0.620 0.599	- - - 40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869			
1* 2* 3* 4* 5* 6* 7*	r -5.094 -21.978 14.759 -12.484 -12.647	Unit mm Surface dat d 2.25 0.05 2.61 1.35 0.50	nd 1.53368 1.84666	55.90 23.77	0.563	- - - 40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08			
1* 2* 3* 4* 5* 6* 7* 8* 9	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61	nd 1.53368 1.84666 1.58364 1.49700 1.61800	55.90 23.77 30.30 81.61 63.33	0.563 0.620 0.599 0.538 0.544	- - - 40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869			
1* 2* 3* 4* 5* 6* 7* 8* 9	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70	nd 1.53368 1.84666 1.58364 1.49700	55.90 23.77 30.30 81.61	0.563 0.620 0.599 0.538	40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000			
1* 2* 3* 4* 5* 6* 7* 8* 9	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75	nd 1.53368 1.84666 1.58364 1.49700 1.61800	55.90 23.77 30.30 81.61 63.33	0.563 0.620 0.599 0.538 0.544	- - - 40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06			
1* 2* 3* 4* 5* 6* 7* 8* 9 0 1 2 (Stop)	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047	55.90 23.77 30.30 81.61 63.33 34.71	0.563 0.620 0.599 0.538 0.544 0.583	40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000			
1* 2* 3* 44* 5* 6* 7* 8* 9 0 1 2 (Stop) 3	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75	nd 1.53368 1.84666 1.58364 1.49700 1.61800	55.90 23.77 30.30 81.61 63.33	0.563 0.620 0.599 0.538 0.544	40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06			
1* 2* 3* 44* 55* 66* 77* 88* 9 0 1 2 (Stop) 3 4 5	-5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 & -16.089	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.72047	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33	0.563 0.620 0.599 0.538 0.544 0.583 0.583	40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface			
1* 2* 3* 4* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047	55.90 23.77 30.30 81.61 63.33 34.71	0.563 0.620 0.599 0.538 0.544 0.583	40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09			
1* 2* 3* 4* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6* 7*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61	0.563 0.620 0.599 0.538 0.544 0.583 0.583 0.544 0.538	40	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08,			
1* 2* 3* 44* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6* 7* 8*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179 12.193	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05 2.41	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.72047	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33	0.563 0.620 0.599 0.538 0.544 0.583 0.583	40 45	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface			
1* 2* 3* 44* 5* 6* 77* 88* 9 0 1 2 (Stop) 3 4 5 6* 77*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61	0.563 0.620 0.599 0.538 0.544 0.583 0.583 0.544 0.538	40 45	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000			
1* 2* 3* 44* 55* 66* 77* 88* 9 0 1 2 (Stop) 3 4 5 66* 77* 88* 99* 00*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 ∞ -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05 2.41 0.56	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 81.61	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538	40 45	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08,			
1* 2* 3* 44* 55* 66* 77* 88* 90 01 1 (Stop) 3 4 5 66* 77* 88* 99* 00* 11* 2*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -1533.737 14.750	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05 2.41 0.56 0.46 0.46 1.63 1.84	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 81.61	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538	40 45	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08, A10 = -1.23320e-09			
1* 2* 3* 44* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6* 7* 8* 9* 0* 1* 2* 3*	-5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 α -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -15.33.737 14.750 -19.850	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 0.58 0.05 1.91 0.05 2.41 0.56 0.46 1.63 1.84 4.58	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700 1.58364 1.63490	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 81.61 30.30 23.88	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538 0.599 0.630	40 45	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08,			
1* 2* 3* 44* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6* 7* 8* 9* 00* 1 2 3* 4 4*	-5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 ∞ -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -1533.737 14.750 -19.850 -8.763	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05 2.41 0.56 0.46 1.63 1.84 4.58 0.50	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700 1.58364	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 81.61 30.30	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538 0.538	40 45 50	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08, A10 = -1.23320e-09			
1* 2* 3* 4* 5* 60* 7* 88* 9 0 1 2 (Stop) 3 4 5 66* 7* 88* 99* 00* 11* 23* 44* 55*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -1533.737 14.750 -19.850 -8.763 -22.584	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 1.58 0.05 1.91 0.05 2.41 0.50 1.63 1.84 4.58 0.50 1.25	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 30.30 23.88 55.90	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538 0.599 0.630 0.563	40 45 50	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08, A10 = -1.23320e-09 24th surface k = -0.003 A4 = -2.69363e-03, A6 = 5.72972e-05, A8 = -2.11668e-06,			
1* 2* 3* 44* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6* 7* 8* 9* 0* 11* 2* 3* 44* 5* 6*	-5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 ∞ -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -1533.737 14.750 -19.850 -8.763	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05 2.41 0.56 0.46 1.63 1.84 4.58 0.50	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700 1.58364 1.63490	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 81.61 30.30 23.88	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538 0.599 0.630	40 45 50	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08, A10 = -1.23320e-09 24th surface k = -0.003 A4 = -2.69363e-03, A6 = 5.72972e-05, A8 = -2.11668e-06, A10 = -1.79590e-08			
1* 2* 3* 44* 5* 6* 7* 8* 9 0 1 2 (Stop) 3 4 5 6 6* 7* 8* 9* 01 11 12 22 23 33 44 55 66 77 88	-5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -1533.737 14.750 -19.850 -8.763 -22.584 -5.430 17.171	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 1.91 0.05 2.41 0.56 0.46 1.63 1.84 4.58 0.50 1.25 0.50 1.00 0.30	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 30.30 23.88 55.90	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538 0.599 0.630 0.563	40 45 50	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08, A10 = -1.23320e-09 24th surface k = -0.003 A4 = -2.69363e-03, A6 = 5.72972e-05, A8 = -2.11668e-06,			
3* 4* 5* 6* 7* 8*	r -5.094 -21.978 14.759 -12.484 -12.647 -300.282 8.853 -6.900 -25.846 -5.005 8.524 -16.089 10.367 -11.398 14.113 -13.179 12.193 -16.975 -11.963 -1533.737 14.750 -19.850 -8.763 -22.584 -5.430 17.171	Unit mm d 2.25 0.05 2.61 1.35 0.50 0.05 2.98 0.75 1.61 0.70 2.75 0.24 0.70 1.58 0.05 2.41 0.56 0.46 1.63 1.84 4.58 0.50 1.25 0.50 1.00	nd 1.53368 1.84666 1.58364 1.49700 1.61800 1.72047 1.61800 1.49700 1.58364 1.63490 1.53368 1.53368	55.90 23.77 30.30 81.61 63.33 34.71 34.71 63.33 81.61 81.61 30.30 23.88 55.90 55.90	0.563 0.620 0.599 0.538 0.544 0.583 0.544 0.538 0.538 0.599 0.630 0.563	40 45 50	A4 = 1.31025e-04, A6 = -4.14291e-07, A8 = -1.11771e-07 17th surface k = -0.030 A4 = 5.11989e-06, A6 = 1.41228e-06 18th surface k = 0.000 A4 = 3.58772e-05, A6 = 3.68790e-06 19th surface k = -0.665 A4 = -9.13946e-05, A6 = -9.02423e-06, A8 = -1.32639e-07 20th surface k = -0.869 A4 = 9.86704e-05, A6 = -1.97220e-05, A8 = 3.10896e-08 21th surface k = 0.000 A4 = 1.09340e-04, A6 = 1.74012e-06 22th surface k = -7.881 A4 = 4.76596e-05, A6 = 1.36921e-06, A8 = -6.41081e-08, A10 = -1.98830e-09 23th surface k = 0.000 A4 = -1.16502e-04, A6 = -1.10099e-07, A8 = -1.34141e-08, A10 = -1.23320e-09 24th surface k = -0.003 A4 = -2.69363e-03, A6 = 5.72972e-05, A8 = -2.11668e-06, A10 = -1.79590e-08			

A4 = -1.49191e-04, A6 = -1.19921e-05, A8 = -8.57893e-07

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	-cc	ontinue	d					-(continue	æd		
	Į	Jnit mm							Unit mm			
26th surfa	ice					·	<u>8</u> t	h surface				
k = 0.000 $A4 = -2.5$ 27th surfa	57594e-04, A6 = 1.1	6204e-05	5, A8 = -9.02	2596e-07			k - A- 16					
	41 55930e-03, A6 = 7.9 79066e-08	1869e-05	5, A8 = -3.96	5242e-06,		10	k = -0.579 $A4 = 7.50799e-06$ 17th surface					
	Va	rious data	ı			-	A	= 0.000 4 = -8.03928e	-05			
N.	A			0.23		15	18	8th surface				
M Fo	agnification ocal length				A	= 0.000 4 = 2.62042e- th surface	04					
fb	Image height (mm) 4.75 fb (mm) (in air) 2.50 Lens total length (mm) (in air) 36.35						A	= 0.000 4 = 2.02927e- 0th surface	08			
	Exa	ample 7	'9				A	= 0.000 4 = 1.22996e- th surface	05			
						25	A	= 0.000 4 = 1.31433e- 2th surface	04			
	J	Jnit mm					k	= 0,000				
	Su	rface data				30	A	4 = 1.29005e- 3th surface	10			
urface no.	29.347	d 3.01	nd 1.84666	vd 23.77	θgf 0.620	•		= 0.000 4 = -8.96164e	-11			
2* 3	-36.004 -397.741	0.10 0.70	1.65412	39.68	0.574			th surface				
4	21.124	0.10				35	k	= 0.000				
5 * 6	19.426 -31.982	4.27 0.10	1.49700	81.61	0.538			4 = 3.63415e- 5th surface	11			
7	20.342	3.53	1.49700	81.61	0.538		2.	oui surrace				
8 * 9	-22.961 -172.666	0.10 2.93	1.61800	63.33	0.544			= 0.000 4 = -8.06302e	04.46-	6 956610	06	
Ó	-11.505	0.70	1.72047	34.71	0.583	40 -	A	4 = -8.003020	-04, A0 -	0.630046-		
1 2 (Stop)	24.226 ∞	0.79 0.17				40		7	⁄arious da	ta		
3	-243.374	0.70	1.90366	31.32	0.595		NA				0.38	
1 -	9.660	3.41	1.61800	63.33	0.544		Magnif				-2.20	
5 6*	-43.351 11.180	0.10 4.50	1.49700	81.61	0.538		Focal l	ength height (mm)			5.02 4.92	
7*	-10186.757	8.48	1.15700	01.01	0.550	45		ı) (in air)			2.50	
3* 	719.997	0.70	1.49700	81.61	0.538			otal length (mr	n) (in air)		54.08	
)*)*	13.006 13.192	6.32 3.44	1.58364	30.30	0.599	_						
1*	-15.080	3.70										
2*	-9.430	0.81	1.49700	81.61	0.538	50		Ex	kample	80		
3* 4*	10.877 -10.747	2.39 0.51	1.53368	55.90	0.563	50						
5*	-3339.876	1.75										
6 7	∞	0.38 0.50	1.51640	65.06	0.535	_			TT !:			
, nage plane	∞ ∞	0.50				_			Unit mm			
	Aspheri	cal surfac	e data			55 _		S	urface dat	a		
	1st surface					· _	Surface no.	r	d	nd	vd	θgf
	k = 0.000					-	1 2*	-4.006 -5.643	2.23 0.10	1.53368	55.90	0.563
	A4 = 1.00145e - 0	5				60	3*	25.874	2.62	1.84666	23.77	0.620
	2nd surface					-	4 5	-8.470 -9.951	0.46 0.50	1 50264	30.20	0.599
	k = 0.000						5 6	-9.951 31.833	0.50	1.58364	30.30	0.399
	A4 = 4.66734e - 0	5					7*	15.267	2.87	1.49700	81.61	0.538
	5th surface					_	8 * 9	-7.030 11.408	0.10 2.73	1 61 000	63.33	0.544
							y	11.408	173	1.61800	6444	11.544
	k = 0.699					65	10	-5.135	0.70	1.72047	34.71	0.583

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						-						
12 (Stop)	∞	0.95				5			Unit mm			
3	-13.978	0.70	1.72047	34.71	0.583	_						
4 5	12.361 -9.042	2.62	1.61800	63.33	0.544	_		S	urface dat	а		
5 5*	-9.042 13.037	0.05 3.38	1.49700	81.61	0.538		Surface no.	. r	d	nd	νd	θgf
0 7*	-8.022	1.85	1.49700	01.01	0.556	_	Surface no.	. 1	u	nu	vu	Ogi
8*	60.912	0.50	1.58364	30.30	0.599	10	1	-4.999	2.50	1.53368	55.90	0.56
9*	10.361	4.64				10	2*	-7.791	0.10			
.0 *	7.593	2.80	1.63490	23.88	0.630		3*	26.421	2.58	1.84666	23.77	0.62
21	57.244	3.84					4 5	-8.717 -16.546	0.45 0.50	1.58364	30.30	0.59
22	-9.323	0.50	1.53368	55.90	0.563		6	7.490	0.18	1.50501	50.50	0.55
23 24	402.242 -6.000	1.68 0.50	1.53368	55.90	0.563		7*	7.494	3.51	1.49700	81.61	0.53
25*	39.607	0.90	1.55500	33.90	0.505	15	8*	-6.731	0.10			
26	∞	0.30	1.51640	65.06	0.535		9	8.184	2.60	1.61800	63.33	0.54
27	∞	0.50					10 11	-9.417 5.248	0.70 1.23	1.72047	34.71	0.58
mage plan	e ∞						12 (Stop)	5.246	1.08			
<i>O</i> 1						_	13	-8.120	0.70	1.72047	34.71	0.58
	Aspheri	cal surfa	ce data			20	14	263.853	2.25	1.61800	63.33	0.54
	•					-	15	-8.897	0.05			
	2nd surface						16*	14.031	3.32	1.49700	81.61	0.53
						_	17*	-8.260	0.05	1 40700	01.61	0.53
	k = 0.000						18* 19*	16.860 32.221	1.79 0.80	1.49700	81.61	0.53
	A4 = 2.35623e - 0	14				25	20*	38.453	0.50	1.58364	30.30	0.59
	3rd surface					23	21*	8.351	3.63	1.0000-1	50.50	0.07
	-					_	22*	6.933	2.65	1.63490	23.88	0.63
	k = 0.000						23	26.183	4.93			
	A4 = -2.82645e	-04					24	-6.000	0.50	1.53368	55.90	0.56
	7th surface						25*	12.318	2.01			
	-					30	26	∞	0.30	1.51640	65.06	0.53
	k = 0.000						27 Image plan	∞ e ∞	0.50			
	A4 = -2.81954e-8th surface	-05				-	mage plan					
	our surface					- <u>-</u>			rical surfa	ce data		
	k = 0.000 A4 = 5.97163e - 0	14				35		2nd surface				
	16th surface							k = 0.000				
						_		A4 = 1.99427e -	04			
	k = 0.000							3rd surface				
	A4 = -3.21151e	-04						k = 0.000				
	17th surface					40		A4 = -3.99767e	-04			
						_		7th surface				
	k = 0.000											
	A4 = 4.81608e - 0	15						k = 0.000				
	18th surface							A4 = -2.57298e	-04			
	-					- , ₋		8th surface				
	k = 0.000					45		k = 0.000				
	A4 = 1.49059e - 0	14						A4 = 4.27793e -	04			
	19th surface					_		16th surface				
				_	_			1 0.000				
	k = 0.000	0.4						k = 0.000 A4 = -2.36647e	-04			
	A4 = -1.11086e- 20th surface	-04				50		17th surface	0-1			
	Zom surface					_		-				
	k = 0.000							k = 0.000				
	A4 = -1.48114e	-04						A4 = -2.67152e	-05			
	25th surface	- •						18th surface				
						- 55		k = 0.000				
	k = 0.000							A4 = 2.23589e -	09			
	A4 = -8.65591e	·04, A6 =	-1.95796e-	-05				19th surface				
	V/c	rious dat	·a			-		k = 0.000				
	V	arous uat						A4 = -2.43051e	-09			
NA				0.32		60		20th surface				
	gnification			-2.00				1 0.000				
	al length			3.72				k = 0.000 A4 = -1.76676e	_04			
	ge height (mm)			3.87				A4 = -1.76676e 21th surface	-04			
	mm) (in air)			1.60				zim suiidet				
						65		1 0.000				
	s total length (mm) (in air)		39.40		0.5		k = 0.000				

238

		237							238			
	-	continue	ed					-	continue	ed		
		Unit mm				-			Unit mm			
	22th surface					- - 5		16th surface				
	k = 0.000 $A4 = -2.895420$ 25th surface	e-04				- 3		k = 0.000 A4 = -5.25327 17th surface	e-04			
	k = 0.000 $A4 = -8.76890$	e-04, A 6 =	= 6.34071e-0	06		10		k = 0.000 A4 = 1.12098e- 18th surface	-04			
	1	Various dat	ta			_		k = 0.000				
M Fo	IA Magnification ocal length nage height (mm)			0.32 -2.00 4.27 3.87		15		A4 = -1.70703 19th surface $k = 0.000$ $A4 = -4.89824$				
	o (mm) (in air) ens total length (m	m) (in air)		2.70 39.40		-		20th surface k = 0.000 A4 = -3.06971	e-04			
	E	xample	82			20		23th surface k = 0.000 A4 = -1.00102		4 728600	06	
							-		Various dat		-00	
		Unit mm				_ 25	NA		various dat		0.32	
		Surface dat				-	Ma	gnification cal length			-2.00 4.22	
Surface no.	r	d	nd	νd	θgf	- 30	Im fb	age height (mm) (mm) (in air) ns total length (m	m) (in air)		3.87 2.70 39.40	
1 2*	-5.000 -6.052	2.61 0.10	1.53368	55.90	0.563							
3* 4	29.971 -8.900	2.45 0.10	1.84666	23.77	0.620			Е	xample 8	83		
5 6	-12.880 15.407	0.50 0.28	1.58364	30.30	0.599	35						
7* 8*	14.854 -7.113	2.80 0.10	1.49700	81.61	0.538		1		Unit mm			
9 0	10.444 -6.908	2.55 0.70	1.61800 1.72047	63.33 34.71	0.544 0.583				Surface dat	a		
1 2 (Stop)	5.463 ∞	1.42 1.00	1.72047	54.71	0.303		Surface no.	r	d	nd	νd	θgf
.3	-10.334	0.70	1.72047	34.71	0.583	40	1* 2*	-8.255	2.60	1.53368	55.90	0.563
.5	16.417 -7.780	2.68 0.05	1.61800	63.33	0.544		3*	-14.196 101.410	1.24 6.01	1.84666	23.77	0.620
6* 7*	12.572 -7.222	3.57 1.66	1.49700	81.61	0.538		4* 5*	-20.773 -16.458	6.49 1.50	1.58364	30.30	0.599
8*	-222.930	0.50	1.58364	30.30	0.599	45	6* 7*	115.582	0.05			
9* !0*	9.006 7.379	3.98 2.73	1.63490	23.88	0.630	73	/* 8*	25.167 -58.962	4.74 0.05	1.49700	81.61	0.538
1	40.501	5.73					9*	108.206	3.90	1.49700	81.61	0.538
2 3*	-6.000 11.000	0.50 2.01	1.53368	55.90	0.563		10 * 11	-18.035 262.420	2.69 3.93	1.61800	63.33	0.544
.4	8	0.30	1.51640	65.06	0.535		12	-14.956	0.59	1.72047	34.71	0.583
!5 mage plane	& &	0.50				50	13 14(Stop)	30.541 ∞	6.11 1.38			
						-	15	-26.136	0.63	1.72047	34.71	0.583
	Asphe	rical surfa	ce data			_	16 17	63.605 -37.610	2.51 0.05	1.61800	63.33	0.544
	2nd surface					_	18*	76.408 -22.777	4.37 0.05	1.49700	81.61	0.538
	k = 0.000 $A4 = -1.059366$	11				55	20* 21*	44.456 -44.738	5.20	1.49700	81.61	0.538
	A4 = -1.059366 $3rd surface$	v=11				_	21** 22* 23*	-44.738 -32.651 -325.190	3.37 0.69 0.05	1.58364	30.30	0.599
	k = 0.000 $AA = -3.54087$	=_04					23* 24* 25*	27.615	4.73	1.63490	23.88	0.630
	A4 = -3.540876 $7th surface$	z=0 4				60 -	26*	-102.253 -14.459	19.80 0.70	1.53368	55.90	0.563
	k = 0.000 A4 = -4.91474	04					27* 28* 29*	-111.000 -17.656 110.376	2.16 1.10 1.20	1.53368	55.90	0.563
	A4 = -4.914/4	-04					30	110.376 ∞	0.30	1.51640	65.06	0.535
	our surface					_	31	∞	0.50			

-continued

Unit mm				Unit mm			
Aspherical surface data		26th surfa	ıce				
1st surface		k = -0.38	3				
1. 1.520			30149e-05, $A6 = 4$.72395e-0	7, A8 = -3.5	6824e-09	1
k = -1.539 A4 = 1.48943e - 05, $A6 = -3.89277e - 07$, $A8 = -3.16495e - 10$		27th surfa	ice				
2nd surface		k = 0.000					
1 0 570	10		9150e-05, A6 = -3	.31847e-0	7, A8 = -8.8	9867e-10	1
k = -2.553 A4 = 8.26430e-05, A6 = -3.70903e-07, A8 = -4.35290e-10		28th surfa	ice				
3rd surface		k = 0.000					
		A4 = 5.68					
k = 0.000 A4 = 5.57538e-06, A6 = 3.09183e-09, A8 = -7.06884e-12	15	29th surfa	ice				
4th surface	13	k = -1058					
		A4 = -1.2	26430e-04, A6 = -	5.45019e-	09, A8 = 6.6	6594e–11	
k = -0.148 A4 = 1.09741e-05, A6 = 4.10988e-08, A8 = -1.79459e-11			7	Various dat	a		
A4 = 1.097416 - 0.5, $A0 = 4.109886 - 0.6$, $A6 = -1.794396 - 115th surface$							
	20	N. M	A agnification			0.33 -1.32	
k = -0.223			cal length			9.91	
A4 = 2.76548e-06, A6 = 9.37309e-08, A8 = 1.06388e-10 6th surface			nage height(mm)			10.82	
VIII VIII III			(mm) (in air) ens total length(mn	ı) (in air)		1.90 88.59	
k = -29.473	25		total longth(IIII	., (111 411)		00.07	
A4 = -5.12018e-06, A6 = -1.66723e-08, A8 = 2.66467e-10 7th surface	25						
/ in Stillage							
k = -2.649			E	xample	84		
A4 = 2.86256e-06, A6 = 6.93196e-08, A8 = 2.24500e-10							
8th surface	— 30						
k = 0.000				** '			
A4 = 4.46646e-06, A6 = 2.43563e-08 9th surface				Unit mm			
				Surface dat	a		
k = 0.000 A4 = -6.36933e-06, A6 = -6.27240e-09	35	Surface no.	r	d	nd	vd	θ gf
10th surface		1	5.522	3.32	1.49700	81.54	0.53
1 2004		2	-4.753	0.70	1.72047	34.71	0.583
k = -3.004 A4 = 8.21883e-06, A6 = 8.91877e-08, A8 = 6.92116e-11		3 4*	-6.534 -11.725	0.05 1.03	1.53368	55.90	0.563
18th surface	40	5*	-2.515	0.35	1.55500	55.50	0.50.
	40	6*	2.408	1.07	1.58364	30.30	0.599
k = 0.000		7* 8(Stop)	1.032 ∞	1.34 -0.63			
A4 = 5.10610e-06, $A6 = -7.42857e-08$, $A8 = -1.54961e-1119th surface$		9*	2.834	1.69	1.49700	81.54	0.53
	_	10*	-7.273	0.11	1.502.57	20.20	0.50
k = 0.000	45	11* 12*	-52.231 3.627	0.42 2.78	1.58364	30.30	0.599
A4 = 3.08416e-06, A6 = 2.25200e-08, A8 = -1.04000e-10		13*	-10.317	0.64	1.53368	55.90	0.563
20th surface		14*	-20.884	0.43	4 505 51	20.55	0 = -
k = 0.000		15* 16*	36.783 70.302	0.98 0.36	1.58364	30.30	0.59
A4 = 4.03758e - 06, $A6 = 3.78128e - 09$, $A8 = -8.78028e - 11$		17*	-113.857	2.13	1.53368	55.90	0.56
21th surface	50	18*	-2.520	0.73	1 500 55	55.00	0.5-
k = 0.001		19* 20*	5.467 1.773	1.41 3.00	1.53368	55.90	0.563
A4 = -8.30957e - 06, $A6 = -7.77920e - 08$, $A8 = -7.06650e - 12$		21	o.	0.30	1.51640	65.06	0.53
22th surface		22	∞	2.68			
k = 0.000	55	Image plane	8				
A4 = 1.08913e - 06, $A6 = -3.06879e - 08$, $A8 = -1.47637e - 11$,,,		Asphe	rical surfa	ce data		
23th surface		4th surfac	e				
k = -1487.500		-					
A4 = 1.34349e-06, A6 = 1.87699e-08, A8 = 1.46137e-11		$k = -2.34$ $\Delta 4 = -5.4$	6 17816e-04, A6 = -	1.85200e	.05 A8 1	11713e. (16
24th surface	60	A4 = -3.2 5th surfac	,	1.052006-	·05, A0 = -1	.11/136-0	,,,
k = -1.292							
A4 = 4.79292e-06, A6 = 9.60595e-10, A8 = 1.17371e-10		k = -4.65 A4 = -1.4	6 15735e-03, A6 = 1	.26259e=0	4. A8 = -9 f	7838e=07	
25th surface		6th surfac	,		., = -2.0		
k = -27.655	65	k = -0.42	7				
			i				

-continued		-continued						
Unit mm		Unit mm						
7th surface		4* -29.284 0.05						
k = -1.871	5	5* 4.017 1.87 1.49700 81.61 0.538 6* -15.570 0.05						
A4 = 1.08273e-02, A6 = -1.21053e-04, A8 = -1.09274e-04 9th surface		7 34.714 1.69 1.61800 63.33 0.54 8 -3.637 0.50 1.72047 34.71 0.58. 9 6.126 0.50						
k = -1.286 A4 = -9.36741e-04, A6 = 5.67573e-04, A8 = 9.10428e-05	10	$\begin{array}{cccccccccccccccccccccccccccccccccccc$						
10th surface $ k = -2.245$		12 6.286 2.41 1.61800 63.33 0.54 13 -4.605 0.05 14* 4.993 3.09 1.49700 81.61 0.53						
A4 = -4.60559e-03, A6 = 8.95601e-04, A8 = 6.69421e-06 11th surface		15* -10.575 4.34 16* -3.072 0.50 1.58364 30.30 0.59						
k = -934.669 A4 = -1.82784e-02, A6 = 2.13051e-03, A8 = -1.14784e-04	15	17* 12.916 3.27 18* 34.808 2.40 1.63490 23.88 0.63 19* -5.789 0.05						
12th surface k = -5.112		20* 5.466 3.30 1.53368 55.90 0.56 21* 2.769 2.00						
K = -3.112 A4 = -4.07687e-04, A6 = -4.69186e-04, A8 = 1.51357e-04 13th surface	20	22						
k = -0.526		Image plane Aspherical surface data						
A4 = -3.38283e-04, A6 = 3.66199e-05, A8 = 6.67864e-06 14th surface		1st surface						
k = -0.958 A4 = 2.56611e-04, A6 = -1.97950e-05, A8 = -3.52754e-07 15th surface	25	k = -12.202 A4 = 1.84539e-03, A6 = 3.72790e-04, A8 = -1.11934e-05 2nd surface						
k = -0.461 A4 = -4.06730e-05, A6 = 6.44269e-06, A8 = -9.11321e-07 16th surface	30	k = -1.452 A4 = 1.42284e-04, A6 = -2.93804e-05, A8 = 1.26134e-05						
k = -633.160 A4 = -8.54163e-03, A6 = 7.70310e-04, A8 = -2.24802e-05 17th surface	_	3rd surface k = -0.043 A4 = 2.43901e-04, A6 = -5.83025e-06, A8 = 2.13535e-06 4th surface						
k = -9931.442 A4 = -9.69825e-03, A6 = 9.38022e-04, A8 = -3.70711e-05 18th surface	35	k = -234.585 A4 = 3.56864e-04, A6 = 4.51097e-05, A8 = 6.12625e-07						
k = -3.263 A4 = -3.49796e-03, A6 = 2.98375e-04, A8 = -1.72732e-05 19th surface	40	5th surface k = -2.940						
k = 0.012 A4 = -2.75744e-03, A6 = 1.27065e-04, A8 = -1.14029e-05 20th surface	40	A4 = -8.89164e-04, A6 = -7.32674e-05, A8 = -4.90767e-06 6th surface k = 4.395						
k = -2.861 A4 = -1.60534e-03, A6 = 1.89038e-04, A8 = -1.72789e-05	45	A4 = 2.86421e-05, A6 = -8.09298e-05, A8 = -2.56197e-06 14th surface						
Various data		k = -0.616 A4 = -4.85884e-04, A6 = -3.21813e-06, A8 = -2.60788e-07						
NA 0.42 Magnification -2.54		15th surface						
Focal length 5.60 Image height(mm) 2.82 fb(mm) (in air) 5.88	50	k = 0.121 A4 = 3.77898e-05, A6 = -2.13024e-05, A8 = 5.58090e-07 16th surface						
Lens total length(mm) (in air) 24.78		k = -0.444 A4 = 2.49937e - 03, $A6 = -2.65748e - 05$, $A8 = -3.54361e - 0617th surface$						
Example 85		k = 0.000 A4 = 1.53490e-03, A6 = 1.15188e-04, A8 = -1.26803e-05 18th surface						
Unit mm	60	k = -55.238						
Surface data	_	A4 = -4.63820e-04, A6 = -5.23030e-05, A8 = 4.97870e-07, A10 = 3.80003e-08 19th surface						
Surface no. r d nd vd 0gf 1* -5.514 1.29 1.53368 55.90 0.563 2* -11.922 0.05 3* 5.778 1.67 1.63490 23.88 0.630	3 65	k = -0.135 A4 = 7.41400e-05, A6 = 7.36376e-06, A8 = -1.55794e-06, A10 = 3.62379e-08						

2 13	- '
continued	-cont

		443					244		
	-continued						-continued		
		Unit mm					Unit mm		
20th surface						 - 5	5th surface		
k = -1.532 $A4 = -8.00176$ $A10 = -7.5057$ $21th surface$		13990e-(05, A8 = 2.02	:773e-06,		_	k = -2.606 A4 = -3.31913e-04, A6 = 5.07700e-06, A8 6th surface	8 = -4.37050e-06	
k = -0.303 A4 = -7.75557e-03, A6 = 1.59034e-05, A8 = -1.60847e-06,						10	k = 6.614 A4 = -1.77928e-04, A6 = -3.96916e-05, A 14th surface	A8 = -5.59983e-07	
A10 = -3.3050		arious da	ta			-	k = -0.665 A4 = -6.37173e-04, A6 = 3.43918e-06, A8 15th surface	8 = -3.68651e-07	
NA Magnif Focal le Image				0.40 -2.58 6.09 2.86		15	k = -0.288 A4 = 6.95438e-05, A6 = -1.77347e-05, A8 = 4.94606e-07 16th surface		
fb(mm)) (in air) otal length(mm	ı) (in air)		3.40 31.54		20	k = -0.710 A4 = 4.67166e-03, A6 = -3.63236e-04, A8 17th surface	8 = 1.79484e-05	
Example 86							k = -0.162 A4 = 4.32027e-03, A6 = -4.81582e-05, A8 18th surface	8 = 5.13546e-06	
		Unit mm				25 -	k = -0.001 A4 = -2.62657e-04, A6 = -2.72183e-04, A A10 = 1.73439e-07 19th surface	A8 = 8.71964e-06,	
						_	19th Surface		
	S	urface da	ta			- 30	k = 0.002	10 200002- 00	
Surface no.	r	d	nd	νd	θgf	_	A4 = -3.81707e-04, A6 = -1.42470e-05, A A10 = 8.83630e-08 20th surface	48 = -2.09083e-00,	
1* 2*	-2.994 -8.073	0.88 0.05	1.53368	55.90	0.563		k = -2.233		
3*	6.018	1.86	1.63490	23.88	0.630		A4 = -1.78749e - 03, $A6 = 1.38140e - 04$, $A8$	8 = 1.79702e-05,	
4* 5*	-20.490	0.05	1 40700	01.61	0.530	35	A10 = -6.32913e - 07		
5* 6*	3.224 -12.832	2.35 0.05	1.49700	81.61	0.538		21th surface		
7	-29.415	1.62	1.61800	63.33	0.544		k = -0.253		
8	-3.584	0.50	1.72047	34.71	0.583		A4 = -1.47421e - 02, $A6 = 2.66260e - 04$, $A8$	8 = -2.46439e - 06	
9	8.995	0.50					A10 = 3.18446e - 07		
10(Stop)	∞ 4.207	0.63	1 72047	2471	0.502	40			
11 12	-4.307 7.428	0.50 2.35	1.72047 1.61800	34.71 63.33	0.583 0.544		Various data		
13	-4.986	0.05	1.01000	00.00	0.277	_	NA	0.40	
14*	4.490	3.26	1.49700	81.61	0.538		Magnification	-1.99	
15*	-11.421	3.45					Focal length	5.65	
16*	-3.264	0.50	1.58364	30.30	0.599	45	Image height(mm)	2.30	
17*	16.176	2.44			0.750	45	fb(mm) (in air)	3.00	
18*	30.183	2.05	1.63490	23.88	0.630		Lens total length(mm) (in air)	29.24	
19* 20*	-5.566 4.781	0.05	1.53368	55.90	0.563	-			
21*	2.375	3.10 2.00	1.55500	JJ. 3 0	0.303				
22	oo	0.30	1.51640	65.06	0.535		Example 87		
23	∞	0.80		00		50	Example 87		
Image plane	œ					_			
	Asphei	rical surfa	ce data			-	Unit mm		
1st surface						-	Surface data		
k = -3.628 A4 = 2.21200e	:-03 A6 = -2	31 <i>74</i> 8e_0)4 A8 = 5 0?	955e=05		55 _		nd vd 0g	
2nd surface	. 55,1102.	21,100-0	,	05		_	Janes III.	, , ,	

1* 2* 3* 4* 5*

8 9

11

10(Stop)

-3.798

-6.396 7.086

7.086 -9.324 3.430 -13.065 -11.385 -3.594 16.094

∞ -16.057

0.05 2.06

0.18 2.38 0.06

1.90

0.50 0.33

0.33

0.50

1.53368

1.63490

1.49700

1.61800

1.72047

1.72047

23.88

81.61

63.33

34.71

34.71

0.563

0.630

0.538

0.544 0.583

0.583

1st surface	
k = -3.628 A4 = 2.21200e - 03, $A6 = -2.31748e - 04$, $A8 = 5.92955e - 052nd surface$	5:
k = -4.147 A4 = 1.98768e-04, A6 = -1.64515e-04, A8 = 1.62766e-05 3rd surface	61
A4 = 1.23394e-04, A6 = 5.43421e-06, A8 = 4.73002e-06 4th surface	
k = -128.688 A4 = 2.32019e-05, A6 = 4.04905e-05, A8 = 8.00733e-06	6.

246

k = -0.972 A4 = -9.54935e-04, A6 = -1.60895e-05, A8 = 9.62636e-07

-continued							-continued					
		Unit mm					Unit mm					
12	5.835	2.86	1.61800	63.33	0.544	- -		V	arious dat	а		
13 14* 15*	-8.690 6.232 -9.315	0.05 4.02 3.51	1.49700	81.61	0.538	, <u> </u>	Magnification -4.18					
16* 17*	-4.074 -8.282	3.92 2.17	1.58364	30.30	0.599		Focal le Image l	ength neight(mm)			2.80 2.23	
18* 19*	-13.370 -7.760	2.21 1.21	1.63490	23.88	0.630	10	fb(mm)	(in air) tal length(mm	(in air)		5.53 39.27	
20*	3.535	3.61	1.53368	55.90	0.563	_	Lens to	tar rength(min	i) (III aII)		37.27	
21* 22	1.476 ∞	4.00 0.30	1.51640	65.06	0.535							
23 Image plane	& &	1.33						Ex	kample :	88		
	Asphe	erical surfa	ice data			- 15						
1st surface									TT :			
k = -0.655	62 04 46	0.620100	02 49 40	24542 0	2	-			Unit mm urface dat	· a		
A4 = -2.80796 $2nd surface$	0e-04, A0 = -	9.039106-	-03, A8 = 4.5	72434e=0.		_ 20 -	Surface no.	r	d	nd	vd	θgi
k = 5.942 A4 = -1.18699	00 02 46 - 7	12083 (M AQ _ 15	36862 0	4	-	1*	-2.732	1.36	1.53368	55.90	0.56
3rd surface	9e-02, A0 = 7	.129636-0	74, A6 = -1.3	30806-04	+	_	2*	-4.589	0.05			
k = -0.447						25	3* 4*	7.247 -8.455	1.87 0.05	1.63490	23.88	0.63
K = -0.447 $A4 = -1.97368$	8e-04, A6 = 6	.28902e=0	05, A8 = -7.4	16102e-0°	7		5*	3.138	2.15	1.49700	81.61	0.53
4th surface						_	6*	-12.154	0.04	1 61 900	62 22	0.54
k = -16.463							7 8	-15.110 -3.447	1.79 0.50	1.61800 1.72047	63.33 34.71	0.54
A4 = 4.483736	e-04, A6 = 1.1	18444e-04	4, A8 = -4.32	2048e-06		20	9	25.308	0.17			
5th surface						_ 30	10(Stop) 11	∞ 110.943	-0.01 0.50	1.72047	34.71	0.58
k = -2.743							12	4.107	2.60	1.61800	63.33	0.54
A4 = -6.97098	8e-04, A6 = -	3.36286e-	-05, A8 = 2.9	94162e-0	7		13	-9.964 5.200	0.05	1.40500	01.61	0.55
6th surface						_	14* 15*	5.280 -11.739	2.65 3.54	1.49700	81.61	0.53
k = 9.641						35	16*	-3.025	2.06	1.58364	30.30	0.59
A4 = -8.56705	A4 = -8.56705e - 04, $A6 = -1.66634e - 05$, $A8 = 4.35943e - 06$				55	17*	-7.825	1.50				
14th surface						_	18* 19*	-15.729 -5.597	2.16 0.34	1.63490	23.88	0.63
k = -0.885							20*	3.756	3.64	1.53368	55.90	0.56
A4 = -8.82094	4e-04, A6 = -	1.12042e-	-05, A8 = 6.2	24152e-0	7		21*	1.383	2.00			
15th surface						_ 40	22 23	& &	0.30 1.54	1.51640	65.06	0.53
k = -0.269							23 Image plane	8	1.34			
$A4 = 1.80079\epsilon$ $16th surface$	e-04, A6 = -4	.28347e-0	95, A8 = 9.77	7123e-07		-		Aspher	rical surfa	ce data		
k = -0.713							1st surface					
A4 = 4.316756 17th surface	e-03, A6 = -2	.71566e-0	04, A8 = 3.38	3626e-06		45	k = -2.227					
k = -0.493						_	A4 = 1.03707e 2nd surface	-03, A6 = -3.	66686e-0	3, A8 = 2.87	7380e-03	
$A4 = 3.60750\epsilon$	e-03, A6 = -1	.95719e-0	04, A8 = 2.22	2810e-06			k = 3.573					
18th surface						- ₅₀	K = 3.5/3 A4 = -1.72203	e-02, A6 = 2.	19859e-0	3, A8 = -3.3	34713e-04	ļ
k = -78.870							3rd surface					
$A4 = 1.08920\epsilon$.97701e-0	94, A8 = 1.06	5145e-05,	,		k = 0.001					
A10 = -4.4740 19th surface	u3e-U/						K = 0.001 A4 = 6.91776e	-04, A6 = 2.8	3494e-05	A8 = 8.434	94e-09	
						_	4th surface	,		, , , , , , ,		
k = -0.052	.	0.55	o .	0000		55	k = -16.058					
A4 = -7.53657		·8.77181e-	-07, A8 = -1	.92215e-0	06,		K = -16.058 A4 = 5.58712e	-04, A6 = 1.2	0511e-04	A8 = -1.10	589e-06	
A10 = 1.95988 20th surface	oc-06					_	5th surface	,		,		
1- 2.024						_	k = -3.338					
k = -2.024 A4 = -4.21997	7e=03 A6 = 1	26487e-0)4 A8 = 1 30	0491e=05		60	A4 = -9.15433	e-04, A6 = 1.	68698e-0	05, A8 = -5.0)4647e-06	5
A4 = -4.21998 A10 = -4.1998		.20-10/6-0	, ,, , 1.0 = 1.35	. ,,10-03,	,	00	6th surface					
21th surface						_	k = 10.493					
						_	A4 = -4.85932	e-04, A6 = -	8.48143e-	-07, A8 = 2.8	37740e-06	5
k = -0.889	6a 02 46 - 2	.042150.0	13 AR = 27	106650 0	1		14th surface					
A4 = -2.88436 A10 = 2.08658		.042136-0	15, A6 = -2.4	+0003e=04	4,	65	k = -0.972					
0 - 2.00036	00-05						K = -0.972 $AA = -0.54035$		1 (0005	05 10 07	2020 05	,

240
-continue

		t:	.d				aant:1				
	-0	continue	ia .				-continued				
		Unit mm					Unit mm				
15th surface						- 5	24				
k = 0.853 A4 = 7.88421e	e-05, A6 = -7.	27968e-0	95, A8 = 1.26	076e-06		-	Image plane ∞				
16th surface							Aspherical surface data				
k = -0.842 A4 = 4.87822e - 03, $A6 = -3.71445e - 04$, $A8 = -1.52508e - 0517th surface$						10	$\frac{1st surface}{k = -88.989}$				
k = -1.191 A4 = 3.67852e-03, A6 = -5.93789e-05, A8 = -5.04387e-06						_	A4 = -5.99357e-03, A6 = 6.73377e-03, A8 = -4.61378e-03 2nd surface				
18th surface k = -144.172						15	k = 5.622 A4 = -9.89655e-03, A6 = 8.20507e-04, A8 = -1.50643e-04 3rd surface				
A4 = 1.13639e A10 = -9.4986 19th surface		17245e-0	4, A8 = 1.97	474e-05,		_	k = -1.540 A4 = -4.59246e-04, A6 = 1.09257e-04, A8 = -3.18105e-06				
k = 0.008 A4 = -8.04993 A10 = -3.5501 20th surface		17608e-0	15, A8 = -2.7	0155e-06	ó,	20	4th surface k = -25.930 A4 = 6.83244e-04, A6 = 1.11972e-04, A8 = -2.05324e-06 5th surface				
k = -2.462 $A4 = -6.02434$ $A10 = -1.3105$		5.10236e-	·07, A8 = 4.0	6972e-05	5,	25	k = -3.141 A4 = -3.44558e-04, A6 = -5.70704e-06, A8 = -5.53375e-08 6th surface				
21th surface k = -0.990		28101e=0	3 A8 = -2 9			_	k = 7.221 A4 = -9.36274e-04, A6 = -1.66819e-05, A8 = 2.04119e-06 14th surface				
A4 = -3.54488e-02, A6 = 4.28101e-03, A8 = -2.94472e-04, A10 = 1.55285e-05						3 0	k = -1.090				
NA 0.75						-	A4 = -7.88092e-04, A6 = -1.01703e-05, A8 = 3.83265e-07 15th surface				
Magnif Focal le Image l	Magnification -4.18 Focal length 1.99 Image height(mm) 2.30 fb(mm) (in air) 3.74					35	k = -24.035 A4 = 8.25593e-05, A6 = 1.53390e-06, A8 = -6.89536e-09 16th surface				
	otal length(mm) (in air)		30.73		-	k = -3.821 A4 = -3.09218e-05, A6 = 1.81194e-07, A8 = 1.48021e-07				
Example 89						40	17th surface k = -0.514 A4 = 1.71442e-04, A6 = -2.85613e-05, A8 = 5.77601e-07				
							18th surface				
		Unit mm				-					
		Unit mm urface dat	a			- - 45	18th surface k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface				
Surface no.	r	urface dat	nd	vd	θgf	- - 45	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112				
1* 2*	r -5.138 -6.198	urface dat d 2.14 0.05	nd 1.53368	55.90	0.563	- -	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface				
1*	r -5.138	urface dat d 2.14	nd		-	- - 45 - - 50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06				
1* 2* 3* 4* 5*	r -5.138 -6.198 8.105 -11.185 3.574 -13.843	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05	nd 1.53368 1.63490 1.49700	55.90 23.88 81.61	0.563 0.630 0.538	- -	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07				
1* 2* 3* 4* 5*	r -5.138 -6.198 8.105 -11.185 3.574	urface date d 2.14 0.05 2.22 0.05 3.37	nd 1.53368 1.63490	55.90 23.88	0.563	- -	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06,				
1* 2* 3* 4* 5* 6* 7 8	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.202	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12	nd 1.53368 1.63490 1.49700 1.61800	55.90 23.88 81.61 63.33	0.563 0.630 0.538 0.544	- -	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635				
1* 2* 3* 4* 5* 6* 7	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610	d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53	nd 1.53368 1.63490 1.49700 1.61800	55.90 23.88 81.61 63.33	0.563 0.630 0.538 0.544	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06,				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11	s r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.202 \$\infty\$ -29.837 7.231	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99	nd 1.53368 1.63490 1.49700 1.61800 1.72047	55.90 23.88 81.61 63.33 34.71	0.563 0.630 0.538 0.544 0.583	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11 12 13 14*	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.20229.837 7.231 -33.219 7.572	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99 0.05 2.49	nd 1.53368 1.63490 1.49700 1.61800 1.72047	55.90 23.88 81.61 63.33 34.71	0.563 0.630 0.538 0.544 0.583	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06, A10 = 1.63697e-08 22th surface				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11 12 13 14* 15*	-5.138 -6.198 -6.198 -8.105 -11.185 -3.574 -13.843 -14.787 -4.610 125.202 -29.837 -7.231 -33.219 -7.572 -27.697	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99 0.05 2.49 0.10	nd 1.53368 1.63490 1.49700 1.61800 1.72047 1.61800 1.49700	55.90 23.88 81.61 63.33 34.71 34.71 63.33 81.61	0.563 0.630 0.538 0.544 0.583 0.544 0.583	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06, A10 = 1.63697e-08				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11 12 13 14*	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.20229.837 7.231 -33.219 7.572	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99 0.05 2.49	nd 1.53368 1.63490 1.49700 1.61800 1.72047 1.61800	55.90 23.88 81.61 63.33 34.71 34.71 63.33	0.563 0.630 0.538 0.544 0.583 0.583 0.544	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06, A10 = 1.63697e-08 22th surface k = -1.372 A4 = -4.25916e-03, A6 = 3.29135e-05, A8 = 1.23251e-05, A10 = -3.44890e-07				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18*	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.202 -29.837 7.231 -33.219 7.572 -27.697 33.001 -10.371 -4.952	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99 0.05 2.49 0.10 3.56 2.80 1.36	nd 1.53368 1.63490 1.49700 1.61800 1.72047 1.61800 1.49700	55.90 23.88 81.61 63.33 34.71 34.71 63.33 81.61	0.563 0.630 0.538 0.544 0.583 0.544 0.583	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06, A10 = 1.63697e-08 22th surface k = -1.372 A4 = -4.25916e-03, A6 = 3.29135e-05, A8 = 1.23251e-05,				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18* 19*	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.202 -29.837 7.231 -33.219 7.572 -27.697 33.001 -10.371 -4.952 -14.665	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99 0.05 2.49 0.10 3.56 2.80 1.36 3.75	nd 1.53368 1.63490 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700 1.58364	55.90 23.88 81.61 63.33 34.71 34.71 63.33 81.61 81.61 30.30	0.563 0.630 0.538 0.544 0.583 0.544 0.538 0.538 0.538	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06, A10 = 1.63697e-08 22th surface k = -1.372 A4 = -4.25916e-03, A6 = 3.29135e-05, A8 = 1.23251e-05, A10 = -3.44890e-07				
1* 2* 3* 4* 5* 6* 7 8 9 10(Stop) 11 12 13 14* 15* 16* 17* 18*	r -5.138 -6.198 8.105 -11.185 3.574 -13.843 -14.787 -4.610 125.202 -29.837 7.231 -33.219 7.572 -27.697 33.001 -10.371 -4.952	urface dat d 2.14 0.05 2.22 0.05 3.37 0.05 2.55 0.53 0.12 0.37 0.53 2.99 0.05 2.49 0.10 3.56 2.80 1.36	nd 1.53368 1.63490 1.49700 1.61800 1.72047 1.61800 1.49700 1.49700	55.90 23.88 81.61 63.33 34.71 34.71 63.33 81.61 81.61	0.563 0.630 0.538 0.544 0.583 0.583 0.544 0.538	50	k = -0.768 A4 = 3.97431e-03, A6 = -1.53083e-04, A8 = 1.20068e-06 19th surface k = 0.112 A4 = 3.02336e-03, A6 = -1.24246e-04, A8 = 1.29603e-06 20th surface k = -105.496 A4 = 7.78025e-04, A6 = -2.00034e-04, A8 = 6.78493e-06, A10 = -2.09010e-07 21th surface k = -0.635 A4 = -4.86148e-04, A6 = -4.19913e-07, A8 = -1.09125e-06, A10 = 1.63697e-08 22th surface k = -1.372 A4 = -4.25916e-03, A6 = 3.29135e-05, A8 = 1.23251e-05, A10 = -3.44890e-07 23th surface				

249	
-continued	

250 -continued

	-(continu	ea			_		-0	continue	ea		
		Unit mm							Unit mm			
	V	⁄arious da	ta			_ 5	8 9	-10.000 9.606	0.50 2.02	1.76182	26.52	0.613
NA				0.95			10(Stop)	∞	0.10			
Magnif				-8.37			11	59.973	0.50	1.84666	23.78	0.620
Focal le				2.62			12	7.193	2.80	1.65160	58.55	0.542
	neight (mm)			2.30			13	-15.686	0.10	1 40700	01.61	0.520
) (in air)	-		15.35		10	14 15	7.063 -11.667	3.37 0.75	1.49700	81.61	0.538
Lens to	tal length (mn	n) (m air)		52.72		- 10	16	-11.007 -9.306	5.00	1.63980	34.46	0.592
						•	17	6.435	4.14	1.03960	34.40	0.392
							18	19.482	2.64	2.00100	29.13	0.600
	Ex	kample	90				19	-12.687	1.49	2.00100	25.15	0.000
	L	campic	<i>7</i> 0				20	-10.019	0.50	1.43875	94.93	0.534
						15	21	6.821	0.73			
							22	7.316	5.00	2.00100	29.13	0.600
						-	23	8.425	4.00			
		Unit mm					24	∞	0.30	1.51640	65.06	0.535
	S	urface da	ta			-	25 Image pla	∞ ine ∞	0.36			
Surface no.	r	d	nd	vd	θgf	20		V	arious da	ta		
1	-10.000	5.00	2.00100	29.13	0.600	-	N	Δ			0.41	
2	14.403	4.74	1.90366	31.32	0.595			agnification			-2.04	
3	-10.848	0.13			-			cal length			9.96	
4	19.239	3.06	1.84666	23.78	0.620	2.5	Im	nage height(mm)			2.25	
5	-35.634	2.85				25	fb	(mm) (in air)			4.55	
6	11.706	2.97	1.49700	81.61	0.538		Le	ens total length(mm	i) (in air)		52.90	
7	-23.462	1.87	1.72916	54.68	0.544							
8	-10.000	0.50	1.76182	26.52	0.613							
9	8.807 ∞	2.18										
10(Stop) 11	160.537	0.10 0.50	1.84666	23.78	0.620	30		Ex	ample	02		
12	7.000	2.91	1.65160	58.55	0.542	50		Εž	kampie	92		
13	-17.489	0.10	1.05100	30.33	0.542							
14	6.830	3.73	1.49700	81.61	0.538							
15	-12.198	0.82										
16	-8.988	2.29	1.72825	28.46	0.608				Unit mm			
17	8.015	2.84				35		_				
18 19	30.017	3.00	1.84666	23.78	0.620			S	urface dat	ta		
20	-9.829 -6.731	4.23 0.50	1.43875	94.93	0.534		Surface no.	r	d	nd	νd	θ gf
21	7.361	0.72	11.15075	5 1155	0.00							
22	7.764	5.00	2.00100	29.13	0.600		1	-10.000	5.49	2.00100	29.13	0.600
23	17.906	4.14				40	2	-61.066	3.34	1.84666	23.78	0.620
24	œ	0.38	1.51640	65.06	0.535	-10	3	-6.934	0.10			
25	00	0.45					4	78.347	5.54	1.84666	23.78	0.620
Image plane	∞						5	-39.821	0.10	1 40700	01.61	0.520
	τ.	arious da	to			-	6 7	11.573 43.659	2.73 0.10	1.49700	81.61	0.538
	v	arious da	ıa			_	8	14.320	4.05	1.69680	55.53	0.543
NA				0.39		45	9	-10.443	0.50	1.72151	29.23	0.605
Magnif	ication			-2.04			10	7.760	2.80			-
Focal le				10.15			11(Stop)	∞	0.10			
	neight (mm)			2.82			12	64.900	0.50	1.84666	23.78	0.620
fb (mm) (in air)			4.84			13	7.618	3.08	1.59522	67.74	0.544
Lens to	tal length (mn	n) (in air)		54.88		_	14	-124.496	0.10			
						- 50	15	14.276	2.92	1.49700	81.61	0.538
							16	-29.492 35.576	17.45	1.40700	01 61	0.529
	г	1	Ω1				17 18	35.576 10.934	8.57 6.60	1.49700	81.61	0.538
	Ex	kample	91				18	22.042	6.60 2.17	1.84666	23.78	0.620
							20	-346.488	0.10	1.0-000	23.10	0.020
						55	21	10.303	9.00	2.00100	29.13	0.600
						- -	22	5.000	4.00			
		Unit mm					23	∞	0.30	1.51640	65.06	0.535
		urface da				-	24 Image plane	& &	0.36			
Surface no.		d	nd	νd	θgf	-	Be brane		arious dat	ta .		
	r					- 60			arious dai	ıa		
1	-10.000	4.63	2.00100	29.13	0.600		N.				0.74	
2 3	18.300 -0.713	3.42	1.90366	31.32	0.595			agnification ocal length			-4.09 6.20	
3 4	-9.713 14.345	0.10 2.73	1.84666	23.78	0.620			nage height(mm)			6.29 2.25	
5	-82.083	3.46	1.07000	23.70	0.020			(mm) (in air)			4.56	
6	12.268	2.91	1.49700	81.61	0.538	65		ens total length(mm) (in air)		79.91	
7	-11.850	1.47	1.72916	54.68	0.544			<i>8</i> \ <i>m</i>	/			
•												

251 Example 93

252 -continued

									Unit r	nm		
		Unit mm				- 5	23	∞	0.3	6		
		urface dat	a			-	Image plane	∞				
Surface no.		d	nd	νd	θgf	_			Various	data		
1	-10.032	4.92	2.00100	29.13	0.600	- 10		NA Magnification			0.69 -4.09	
2 3	19.088	3.27	1.90366	31.32	0.595	10	1	Focal length			6.84	
4	-9.704 14.300	0.10 2.59	1.84666	23.78	0.620			Image height(mn	1)		2.25	
5	-95.704	3.79						fb(mm) (in air) Lens total length	() (!	:->	5.02 79.91	
6	13.188	2.70	1.49700	81.61	0.538			Lens total length	(mm) (m a	ш)	79.91	
7 8	-11.814 -10.000	1.46 0.50	1.72916 1.76182	54.68 26.52	0.544 0.613	15						
9	9.651	1.97	1.70162	20.32	0.013	10						
10(Stop)	∞	0.10							-	1 05		
11	57.750	0.50	1.84666	23.78	0.620				Examp	le 95		
12	7.886	2.63	1.65160	58.55	0.542							
13	-15.437	0.10	1 40700	01.61	0.539	20						
14 15	6.898 -12.109	3.22 0.76	1.49700	81.61	0.538	20						
16	-9.386	5.00	1.64394	31.87	0.599				Unit n	nm		
17	6.269	4.13	110.55	51.07	0.000				G C	1.4		
18	19.105	2.59	1.96066	27.70	0.596				Surface	data		
19	-12.400	1.79					Surface no.	r	d	nd	vd	θgf
20	-9.554	0.50	1.43875	94.95	0.545	25						-8-
21 22	6.985 7.392	0.72 5.00	2.00100	29.13	0.600		1	-7.000	2.11	1.53368	55.90	0.563
23	8.938	4.00	2.00100	29.13	0.000		2*	-5.323	0.10			
24	∞	0.30	1.51640	65.06	0.535		3*	22.215	2.37	1.84666	23.77	0.620
25	œ	0.35					4 5	-9.110 -5.145	2.81 0.50	1.60999	27.48	0.620
Image plan	e ∞					30	6	-11.263	0.00	1001.00000	-3.45	0.020
	7	7 1 1 4				_	7	-11.263	0.20	1.63762	34.21	0.594
	V	arious dat	а			_	8	91.067	0.65			
NA NA				0.40			9	83.446	2.36	1.61800	63.33	0.544
	gnification			-2.04			10	-4.282	0.70	1.72047	34.71	0.583
Foc	al length			9.83			11 12(Stop)	-10.570 ∞	0.10 1.06			
	ge height(mm)			2.25		35	12(StOp)	-11.698	0.70	1.72047	34.71	0.583
	nm) (in air)			4.55			14	10.934	2.92	1.61800	63.33	0.544
Len	s total length(mm	i) (in air)		52.90		_	15	-10.364	0.05			
							16*	10.909	3.56	1.49700	81.61	0.538
							17* 18*	-11.347 10.087	2.54 1.66	1.58364	30.30	0.599
	17.	kample !	0.4			40	19*	7.386	4.73	1.36304	30.30	0.399
	152	Kampie :	9 4				20*	13.468	2.76	1.63490	23.88	0.630
							21	-20.719	2.70			
							22	127.874	0.50	1.53368	55.90	0.563
		·				-	23 24	4.905 -6.683	2.69 0.50	1.53368	55.90	0.563
		Unit mm				_ 45	24 25*	42.216	1.10	1.55508	33.90	0.505
	S	urface dat	a				26	∞	0.30	1.51640	65.06	0.535
						_	27	∞	0.30			
Surface no.	r	d	nd	νd	θgf	_	Image plane	00				
1	-10.000	8.75	1.84666	23.78	0.620			As	pherical su	ırface data		_
2 3	-7.538 -519.674	0.10 2.18	1.84666	23.78	0.620	50		2nd surface				
4	-20.460	3.68	1.04000	23.76	0.020			Ziid surface				
5	11.754	2.66	1.49700	81.61	0.538			k = 0.000				
6	57.369	0.10						A4 = 4.45010e	:-05			
7	12.489	3.87	1.69680	55.53	0.543			3rd surface				
8 9	-10.229 7.301	0.50 2.63	1.72151	29.23	0.605	55		k = 0.000				
10(Stop)	7.301 ∞	0.96						A4 = 8.14332e	-05			
11	-31.688	0.50	1.84666	23.78	0.620			16th surface				
12	8.281	3.25	1.59522	67.74	0.544							
13	-17.511	0.10						k = 0.000				
14	13.000	2.53	1.49700	81.61	0.538	60		A4 = -2.69612	e-04			
15 16	-175.541 -115.321	18.98 0.50	1.49700	81.61	0.538			17th surface				
17	15.268	3.47	1.12700	01.01	0.550			k = 0.000				
18	29.518	2.47	1.84666	23.78	0.620			A4 = 9.67105e	-05			
19	-38.911	10.28						18th surface				
20	9.569	7.36	2.00100	29.13	0.600	65		1 0.000				
21 22	5.000 ∞	4.46 0.30	1.51640	65.06	0.535	03		k = 0.000 A4 = -2.81280)e_05			
22	∞	0.30	1.31040	00.00	0.555			A+ = -2.81280	no=05			

0.70 2.75

0.05

3.39

2.60

1.63

4.22

2.64

2.64

0.50

2.62

0.50

1.10

0.30

0.30

Aspherical surface data

1.72047

1.61800

1.49700

1.58364

1.63490

1.53368

1.53368

1.51640

34.71

63.33

81.61

30.30

23.88

55.90

55.90

0.583 45

0.544

0.538

0.599

0.630

0.563

0.563

 $65.06 \quad 0.535$

-11.693

12.173

-10.862

10.882

-11.666

8.928

6.663

12.130

-24.243

-50.390

5.177

-6.111

-7309.424

 ∞

œ

2nd surface k = 0.000A4 = 2.52174e - 053rd surface k = 0.000A4 = 8.68592e - 05

15 16

17

18* 19*

20* 21* 22* 23 24 25 26 27* 28 29

Image plane

254

	-	253 continu	ed					254 -continued				
		Unit mn	n			1		Unit mm				
	19th surface					5	18th surfa	ce				
	k = 0.000 A4 = 4.63309e-0 20th surface	5				3	k = 0.000 A4 = -2.5 19th surfa					
	k = 0.000 A4 = -7.88627e-05 25th surface						$k = 0.000$ $A4 = 1.10$ $\underline{20th \ surfa}$					
	k = 0.000 A4 = -1.52626e-	03, A6 =	-3.11735e-05				$k = 0.000$ $A4 = -1.7$ $\underline{21th \ surfa}$					
		Various d	ata			15	k = 0.000 $A4 = 4.70$	589e=05				
Foo Im fb(A agnification cal length age height(mm) (mm) (in air) ns total length(m	m) (in air)		0.32 -2.00 3.75 3.87 1.60		20	22th surfa k = 0.000 A4 = -4.1 27th surfa	ce 6768e-05				
							k = 0.000 A4 = -1.8	4423e-03, A6 = -2.683	48e-05			
	-		0.0			25	Various data					
	Е	Example	96			20	NA Magnificatio Focal length Image heigh		0.32 -2.00 3.71 3.87			
		Unit mn	ı			30	fb(mm) (in a	ir)	1.60			
		Surface da	ata			30	Lens total le	ngth(mm) (in air)	39.90			
Surface no.	r	d	nd	vd	θgf		Next, a lens whice forms the lens unit		nit Gf and a lens which			
1 2* 3*	-7.000 -5.934 33.139	2.16 0.10 2.32	1.53368 1.84666	55.90 23.77	0.563 0.620	35	- Torins the lens time	or are shown belo	···			
4 5	-9.292 -191.804	0.10 1.74	1.49700	81.61	0.538			Lens unit Gf	Lens unit Gr			
6 7	-17.291 -5.386	2.00 0.50	1.60999	27.48	0.620		Example1 Example2	L1~L5 L1~L5	L6~L10 L6~L10			
8	-3.386 -11.263	0.00	1.00999	-3.45	0.020		Example2 Example3	L1~L3 L1~L6	L0~L10 L7~L12			
9	-11.263	0.20	1.63762	34.21	0.594	40	Example4	L1~L5	L6~L11			
10	23.280	0.72					Example5	L1~L5	L6~L8			
11	30.025	2.34	1.61800	63.33	0.544		Example6	L1~L4	L5~L8			
12	-4.979	0.70	1.72047	34.71	0.583		Example7	L1~L4	L5~L8			
13	-10.584	0.10										
14 (Stop)	∞ –11 693	1.07	1 72047	34 71	0.583	45	Next values of co	onditional express	ions (1) to (15) in each			

Next, values of conditional expressions (1) to (15) in each example are shown below. '-' (hyphen) indicates that there is no corresponding arrangement or conditional expression is not satisfied. Moreover, with respect to the example 6 and the example 7, since there is no pair of lenses which satisfy conditional expression (1) to (3), description for conditional expression (1) to (3) is omitted.

55		Exam- ple1	Exam- ple2	Exam- ple3	Exam- ple4	Exam- ple5
	$(1)\mathbf{r}_{OB}/\mathbf{r}_{TLr}$					
	r1, r21	-1	-1.085	_	_	_
	r3, r19	-1	-1.010	_	_	_
	r5, r17	-1	-0.952	_	_	-1
60	r7, r15	-1	-1.010	_	_	_
	r9, r13	-1	-0.995	_	_	 -1
	r1, r25	_	_	-1	_	
	r3, r23	_	_	-1	_	_
	r5, r21	_	_	-1	_	_
	r7, r19	_	_	-1	_	
65	r9, r17	_	_	-1	_	_
	r11, r15	_	_	-1	_	_

30

-continu	ıec

r1, r23	_	_	_	-1	_	
r5, r17	_		_	-1	_	
r7, r15	_	_	_	-1	_	5
r9, r13	_	_	_	-1	_	5
$(2)\mathbf{r}_{OBr}/\mathbf{r}_{TLf}$						
r2, r20	-1	-0.995	_	_	_	
r4, r18	-1	-1.001	_	_	_	
r6, r16	-1	-0.952	_	_	-1	
r8, r14	-1	-0.990	_	_	_	10
r10, r12	-1	-0.926	_	_	-1	
r2, r24	_	_	-1	_	_	
r4, r22	_	_	-1	_	_	
r6, r20	_	_	-1	_	_	
r8, r18	_	_	-1	_	_	
r10, r16	_	_	-1	_	_	15
r12, r14	_	_	-1		_	
r2, r22	_	_	_	-1	_	
r6, r16	_	_	_	-1	_	
r8, r14	_	_	_	-1	_	
r10, r12	_	_	_	-1	_	
						- 20

$(3)(\mathbf{d}_{OB} - \mathbf{d}_{TL})/(\mathbf{d}_{OB} + \mathbf{d}_{TL})$	Exam- ple1	Exam- ple2	Exam- ple3
d1, d20	0	-0.003	
d3, d18	0	-0.005	_
d5, d16	0	0.013	_
d7, d14	0	0.003	_
d9, d12	0	0.006	_
d1, d24	_	_	0
d3, d22	_	_	0
d5, d20	_	_	0
d7, d19	_	_	0
d9, d17	_	_	0
d11, d17	_	_	0
d1, d22	_	_	_
d5, d16	_	_	_
d7, d14	_	_	_
d9, d12	_	_	_

 $(3)(\mathrm{d}_{OB}-\mathrm{d}_{TL})/(\mathrm{d}_{OB}+\mathrm{d}_{TL})$

Exam-

ple4

Exam-

ple5

d1, d20 d3, d18 d5, d16 d7, d14 d9, d12 d1, d24 d3, d22 d5, d20				0	_	40
d7, d19 d9, d17 d11, d17 d1, d22 d5, d16 d7, d14 d9, d12				- - - - -	- - - - -	50
	Exam- ple1	Exam- ple2	Exam- ple3	Exam- ple4	Exam- ple5	
(4)NA NA' (5)β (6)f _{OB} /f _{TL}	0.25 0.25 -1.00 1.00	0.25 0.25 -0.99	0.25 0.25 -1.00	0.25 0.25 -1.00	0.25 0.15 -1.68	55
$(9)d_1/\Sigma d$ $(7)MTF_{OB}$	0.006	1.01 0.006	1.00 0.009	1.00 0.006	0.60 0.005	

-continued

		Exam- ple6	Exam- ple7
5	(4)NA	0.22	0.17
	NA'	0.17	0.22
	(5)β	-1.27	-0.79
	$(6)f_{OB}/f_{TL}$	0.79	1.27
	(9)d ₁ /Σd	0.024	0.024
	$(7)MTF_{OB}$	61	66
10	$(8)MTF_{TL}$	66	61
	(10)d ₂ /Σd	0.38	0.38
	(11)Δf/Y	-0.0047	-0.0058
	$(12)\theta_{\alpha}$	28.4	25.3
	(13)Δf _{cd} /εd	2.50	2.50
	$(14)d_{SHOR}/d_{SHTL}$	0.88	1.13

Also, values of fc/4 and fc'/4 in each example are shown below.

	Exam-	Exam-	Exam-	Exam-	Exam-
	ple1	ple2	ple3	ple4	ple5
Fc/4	229	229	229	229	229
Fc/4'	229	232	229	229	137
		Exa ple		Exam- ple7	
_	ic/4 ic/4'	20 15		159 201	

Next, values of conditional expressions (15) to (57) in each example are given below. '-' (hyphen) indicates that there is no corresponding arrangement or conditional expression is not satisfied.

(15), (15-1), (15-2)	β
(16)	NA
(17)	$L_{TI}/2Y$
(18)	$(\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C})^2)$
` ′	$(1 + \beta_{G2C} \times \Delta D_{G1dC}/f_{G2C})))/\epsilon_d$
(19)	WD/BF
(20), (20-1)	$2 \times (\text{WD} \times \tan(\sin^{-1}\text{NA}) + Y_{obj})/\phi_s$
(21)	D_{max}/Φ_s
(22)	D_{G1max}/ϕ_s
(23), (23-1)	L_L/D_{oi}
(24), (24-1)	$\frac{-L}{1/\text{vd}_{min}}$ - $\frac{1}{\text{vd}_{max}}$
(25), (25-1)	D_{os}/D_{oi}
(26)	$\phi_{G1o}/(2 \times Y/ \beta)$
(27)	BF/L_L
(28)	BF/Y
(29)	ϕ_{G1o}/R_{G1o}
(30)	D_{G1G2}/ϕ_s
(31), (31-1)	L _{G1} /L _{G2}
(32)	L_{G1s}/L_{sG2}
(33)	$\phi_{G1max}/\phi_{G2max}$
(34)	D_{os}/L_{G1}
(35)	D _{ENP} /Y
(36)	CRA_{obj}/CRA_{img}
(37), (37-1)	f _{G1o} /f
(38), (38-1)	R_{G1o}/WD
(39)	R _{G2} /BF
(40)	$R_{G1i}D_{G1is}$
(41)	f_{G1}/f_{G1}
(42)	$1/\text{vd}_{G1min}$ - $1/\text{vd}_{G1ma}$
(43)	1/vd _{G2min} -1/vd _{G2max}
(45)	D_{p1s}/L_{G1s}
(47)	D_{noni}/L_{G1s}
(49)	D_{sDL}/L_{sG2}
(51)	D_{n1s}/D_{os}
(53)	D_{sn2}/D_{si}
(54)	D_{sn3}/D_{si}
(55)	D_{p2s}/D_{os}
(~~)	-p2s - os

			inued							inued		
(56)			D _{oi} + 0.07 ×	W/D/DE		-	(49)	_		_		_
(57)		D_{os}	$L_{G1} = 0.39$:	× WD/BF			(51) (53)	0.05 0.13	0.05	0.07 0.13	0.05 0.05	0.07 0.11
	Exam-	Exam-	Exam-	Exam-	Exam-	5	(54)	0.85	0.84	0.88	0.84	0.84
	ple8	ple9	ple10	ple11	ple12	-	(55) (56)	0.41 1.08	0.41 1.08	0.50 1.02	0.48 0.92	0.41 0.92
(15) (16)	-1.04 0.15	-1.05 0.21	-1.03 0.15	-1.03 0.15	-1.05 0.18		(57)	-0.23	-0.38	0.31	0.69	0.89
(17) (18)	3.6 10.74	4.2 11.51	3.6 9.01	3.6 10.78	3.6 8.52	10		Exam- ple18	Exam- ple19	Exam- ple20	Exam- ple21	Exam- ple22
(19)	5.80	3.94	5.80	5.80	6.91		(1.5)	•				
(20) (21)	3.54 1.18	2.91 0.92	3.64 1.21	3.64 0.98	2.93 0.53		(15) (16)	-1.04 0.15	-1.00 0.15	-1.33 0.23	-1.33 0.23	-1.33 0.23
(22) (23)	0.25 0.51	0.44 0.63	0.21 0.51	0.23 0.51	0.05 0.58		(17) (18)	3.6 8.44	4.3 -1.96	3.7 3.68	6.1 4.38	4.5 7.50
(24)	0.02	0.02	0.02	0.02	0.03	15	(19)	5.80	14.66	7.34	15.71	20.84
(25)	0.64	0.62	0.64	0.64	0.66		(20)	2.91	3.25	2.49	2.51	2.23
(26)	1.36	1.62 0.12	1.37	1.43	1.42 0.09		(21)	0.60 0.02	0.78	1.02	1.96	0.56 0.07
(27) (28)	0.14 0.88	0.12	0.14 0.88	0.14 0.88	0.09		(22) (23)	0.02	0.50 0.58	0.13 0.69	0.01 0.65	0.58
(29)	0.64	0.61	0.65	0.90	0.14		(24)	0.02	0.02	0.03	0.03	0.03
(30)	0.39	0.38	0.37	0.29	0.29	20	(25)	0.63	0.66	0.54	0.52	0.62
(31) (32)	0.75 0.79	1.06 1.06	0.76 0.79	0.71 0.75	1.00 1.07		(26) (27)	1.37 0.14	1.48 0.05	1.57 0.05	2.47 0.03	2.48 0.03
(33)	1.61	1.51	1.66	1.54	1.59		(28)	0.88	0.38	0.38	0.39	0.29
(34)	3.11	2.03	3.08	3.13	2.40		(29)	0.64	0.92	0.35	0.49	0.93
(35)	5.50	11.95	5.85	6.43	6.26		(30)	0.60	0.24	0.42	0.29	0.07
(36) (37)	0.25 2.64	0.13 2.49	0.24 2.54	0.22 2.11	0.20 2.29	25	(31) (32)	0.55 0.74	0.76 0.82	0.63 0.65	0.37 0.39	0.55 0.59
(38)	0.80	1.46	0.80	0.60	4.80		(33)	1.74	1.56	1.21	1.32	1.85
(39)	1152.63	3.92	-13.88	4.67	19.69		(34)	3.93	2.71	2.19	3.11	3.07
(40) (41)	5.35 1.78	5.59 1.85	5.98 1.69	6.35 1.65	4.24 1.46		(35) (36)	5.45 0.22	8.40 0.18	5.33 0.21	6.28 0.21	5.18 0.26
(42)	0.02	0.02	0.02	0.02	0.03		(37)	2.48	7.65	2.11	2.30	3.80
(43)	0.02	0.02	0.02	0.02	0.03	30	(38)	0.80	0.57	2.38	1.24	0.66
(45)	_	_	_	_	1.00		(39)	-3.99	29134.52	-37.68	8.81	-14.44
(47) (49)	_	_	_	_	0.70 —		(40) (41)	2.83 1.25	13.46 4.74	6.90 1.03	5.27 1.73	15.92 2.37
(51)	0.06	0.05	0.05	0.05	0.05		(42)	0.02	0.02	0.03	0.03	0.03
(53)	0.07	0.09	0.07	0.05	0.04		(43)	0.02	0.02	0.03	0.03	0.02
(54) (55)	0.80 0.35	0.80 0.53	0.80 0.35	0.80 0.35	0.84 0.45	35	(45) (47)	_	1.00 0.77	1.00 0.61	1.00 0.71	1.00 0.73
(56)	0.92	0.91	0.92	0.92	1.07		(49)	_	_	_	—	—
(57)	0.85	0.49	0.82	0.87	-0.29	_	(51) (53)	0.11 0.04	0.05 0.03	0.07 0.09	0.05 0.04	0.04 0.02
	Exam-	Exam-	Exam-	Exam-	Exam-		(54)	0.80	0.92	0.92	0.96	0.95
	ple13	ple14	ple15	ple16	ple17	40	(55) (56)	0.34 0.92	0.40 1.61	0.50 1.20	0.35 1.75	0.35 2.03
(15)	-1.05	-1.05	-1.05	-1.05	-1.05		(57)	1.67	-3.01	-0.67	-3.02	-5.05
(16) (17)	0.13 3.5	0.14 3.7	0.21 4.5	0.18 4.4	0.20 4.1			Exam-	Exam-	Exam-	Exam-	Exam-
(18)	6.04	6.34	10.28	8.68	11.52			ple23	ple24	ple25	ple26	ple27
(19)	7.28	7.67	4.83	3.95	4.59	45						
(20) (21)	4.19	3.70 0.75	2.57	3.46	3.09	45	(15)	-1.33	-2.20	-2.55	-2.55	-2.55
(21)	1.01 0.08	0.73	0.66 0.34	1.30 0.02	1.03 0.24		(16) (17)	0.23 4.6	0.38 5.5	0.43 5.6	0.40 5.2	0.40 5.2
(23)	0.57	0.55	0.68	0.64	0.60		(18)	4.83	7.31	8.28	15.29	15.98
(24)	0.03	0.03	0.03	0.03	0.02		(19)	13.36	6.01	3.71	8.73	7.43
(25) (26)	0.65 1.20	0.68 1.32	0.54 1.47	0.54 1.36	0.56 1.52	50	(20) (21)	2.27 0.66	1.52 0.74	1.26 1.04	1.37 0.86	1.41 0.93
(27)	0.09	0.10	0.08	0.11	0.12		(22)	0.01	0.01	0.06	0.05	0.03
(28)	0.59	0.64	0.67	0.88	0.88		(23)	0.57	0.74	0.78	0.74	0.73
(29) (30)	0.24 0.35	0.26 0.33	0.79 0.66	0.29 0.37	0.47 0.41		(24) (25)	0.03 0.62	0.03 0.46	0.03 0.41	0.03 0.47	0.03 0.46
(31)	0.84	0.98	0.67	0.65	0.60		(26)	2.49	3.73	3.70	4.37	4.38
(32)	0.88	1.03	0.66	0.67	0.62	55	(27)	0.05	0.05	0.06	0.04	0.04
(33)	1.28	1.47	1.06	1.14	1.31		(28)	0.46	0.53	0.63	0.37	0.43
(34) (35)	2.60 5.88	2.61 6.91	2.19 6.85	2.23 6.30	2.68 5.97		(29) (30)	0.86 0.09	0.57 0.08	0.44 0.09	0.47 0.03	0.47 0.04
(36)	0.21	0.19	0.83	0.27	0.27		(31)	0.59	0.08	0.43	0.03	0.04
(37)	2.08	1.93	6.36	5.23	2.43		(32)	0.63	0.46	0.44	0.46	0.45
(38)	2.27	1.99	1.09	2.62	1.52	60	(33)	1.79	1.27	1.09	1.34	1.35
(39)	6.50	9.05	12.80	3.25	156.92		(34)	2.99	2.07	1.79	2.01	2.05
(40) (41)	5.55 1.54	5.34 1.55	4.06 3.77	5.65 4.43	4.77 1.81		(35) (36)	5.53 0.23	5.31 0.16	4.99 0.14	4.22 0.20	4.18 0.18
(42)	0.03	0.03	0.03	0.03	0.02		(37)	-48.46	3.89	3.89	5.56	6.66
(43)	0.03	0.03	0.02	0.02	0.02		(38)	0.71	1.86	2.82	2.26	2.26
(45)	1.00	1.00	1.00	1.00	_	65	(39)	-14.49	-1270.10	12.52	-12.86	-22.66
(47)	0.68	0.71	_	_	_		(40)	15.35	30.48	142.69	-13851.56	-953.80

		-cont	inued						-cont	inued		
(41) (42) (43) (45) (47) (49)	-29.10 0.03 0.02 0.96 0.90	1.39 0.03 0.02 1.00 0.72	1.22 0.03 0.02 1.00 0.73	2.03 0.03 0.02 1.00 0.79	2.35 0.03 0.02 1.00	5	(36) (37) (38) (39) (40)	0.20 4.03 0.67 4.67 14.22 2.63	0.14 1.99 1.88 20.40 8.78 1.14	0.13 1.95 1.98 13.06 6.88 1.15	0.15 1.58 2.27 3.44 7.05	0.16 1.63 2.15 84.44 6.82 1.15
(51) (53) (54) (55) (56)	0.04 0.02 0.92 0.34 1.51	0.05 0.02 0.93 0.51 1.16	0.05 0.03 0.92 0.58 1.04	0.02 0.03 0.95 0.50 1.35	0.02 0.03 0.94 0.49 1.25	10	(41) (42) (43) (45) (47) (49)	0.03 0.02 1.00 0.74	0.03 0.03 1.00 0.65	0.03 0.03 1.00 0.64	1.19 0.03 0.03 1.00 0.66	0.03 0.03 1.00 0.66
(57)	-2.23 Example28	-0.28 Exam- ple29	0.35 Exam- ple30	-1.40 Exam- ple31	-0.85 Exam- ple32	- 15	(51) (53) (54) (55) (56)	0.03 0.01 0.80 0.37 0.93	0.05 0.04 0.95 0.52 1.56	0.06 0.05 0.95 0.53 1.46	0.06 0.06 0.88 0.53 1.00	0.06 0.06 0.88 0.53 1.69
(15) (16) (17) (18)	-1.60 0.40 5.2 14.82	-1.56 0.31 5.2 10.68	-1.55 0.31 5.2 9.97	-2.00 0.20 4.0 13.17	-2.00 0.23 4.6 12.33		(57)	0.62 Example38	-2.66 Exam- ple39	-2.07 Exam- ple40	0.30 Exam- ple41	-3.31 Exam- ple42
(19) (20)	8.86 1.50	8.88 1.65	8.96 1.68	8.42 2.02	8.45 1.98	20	(15)	-1.33	-1.30	-1.30	-1.32	-1.32
(21) (22) (23) (24)	0.47 0.03 0.73 0.03	0.63 0.05 0.73 0.03	0.81 0.06 0.73 0.03	0.79 0.02 0.61 0.03	1.15 0.04 0.60 0.03	20	(16) (17) (18) (19)	0.23 5.4 4.49 5.80	0.23 4.9 14.80 7.71	0.23 4.8 12.59 7.83	0.23 4.5 0.65 6.54	0.23 4.5 0.40 6.33
(25) (26) (27)	0.46 3.06 0.04	0.47 2.31 0.04	0.45 2.34 0.04	0.51 2.14 0.07	0.53 2.94 0.07	25	(20) (21) (22)	2.51 0.70 0.04	2.26 0.52 0.19	2.30 0.45 0.20	1.66 0.72 0.71	1.63 0.74 0.74
(28) (29) (30) (31)	0.37 0.72 0.05 0.43	0.37 0.57 0.10 0.47	0.37 0.74 0.08 0.41	0.51 0.47 0.05 0.34	0.60 0.80 0.02 0.37		(23) (24) (25) (26)	0.67 0.03 0.55 2.06	0.70 0.02 0.58 1.88	0.71 0.02 0.60 1.90	0.76 0.03 0.56 1.59	0.76 0.03 0.56 1.52
(32) (33) (34)	0.42 1.20 2.08	0.46 1.13 2.04	0.41 1.08 2.16	0.36 1.14 3.34	0.39 1.59 3.24	30	(27) (28) (29)	0.07 0.74 0.31	0.05 0.45 0.94	0.05 0.43 1.03	0.04 0.37 0.44	0.04 0.37 0.27
(35) (36) (37) (38)	3.79 0.20 6.81 1.63	4.22 0.19 6.71 1.60	3.96 0.20 6.11 1.23	2.46 0.32 7.21 1.06	3.54 0.27 4.16 0.72		(30) (31) (32) (33)	0.33 0.63 0.66 1.31	0.13 0.81 0.82 1.12	0.28 0.92 0.93 1.26	0.28 0.80 0.87 1.31	0.14 0.83 0.86 1.28
(39) (40) (41)	10.52 185.32 2.91	9.98 -988.41 2.82	11.07 -327.47 2.61	16.38 40.51 3.98	-2.99 49.74 3.64	35	(34) (35) (36)	2.22 8.79 0.20	1.88 8.44 0.34	1.84 10.70 0.28	1.77 9.76 0.11	1.65 8.07 0.13
(42) (43) (45) (47)	0.03 0.02 1.00	0.03 0.02 1.00	0.03 0.02 1.00	0.03 0.02 1.00	0.03 0.02 1.00	40	(37) (38) (39) (40)	1.65 2.36 4.40 6.60	2.58 0.88 8.68 -6028.80	1.56 0.84 9.57 17.96	-17.82 2.24 9.83 14.50	2.90 3.64 9.82 161.18
(49) (51) (53)	0.02 0.04	0.02 0.05	 0.03 0.04	0.04 0.02		40	(41) (42) (43)	1.21 0.03 0.03	2.66 0.02 0.02	1.42 0.02 0.02	-5.68 0.03 0.03	0.99 0.03 0.03
(54) (55) (56) (57)	0.95 0.48 1.35 -1.38	0.95 0.49 1.36 -1.42	0.95 0.47 1.36 -1.34	0.72 0.32 1.20 0.05	0.70 0.32 1.19 -0.05	45	(45) (47) (49) (51)	1.00 0.69 — 0.05	 0.06	 0.04	0.95 0.37 — 0.09	1.00 0.41 — 0.09
	Exam- ple33	Exam- ple34	Exam- ple35	Exam- ple36	Exam- ple37	-	(53) (54) (55) (56)	0.05 0.89 0.49 1.08	0.25 0.92 0.55 1.24	0.26 0.92 0.57 1.26	0.04 0.93 0.59 1.21	0.04 0.93 0.63 1.20
(15) (16) (17) (18)	-1.33 0.23 4.5 7.72	-1.33 0.23 4.7 2.62	-1.33 0.23 4.8 3.45	-1.33 0.23 4.9 4.97	-1.33 0.23 5.0 2.00	50	(57)	-0.04 Exam- ple43	-1.13 Exam- ple44	-1.22 Exam- ple45	-0.78 Exam- ple46	-0.81 Exam- ple47
(19) (20)	5.75 2.35	12.05 2.55	10.55 2.55	4.40 2.53	13.69 2.56		(15)	-1.33	-1.33	-1.33	-1.33	-1.33
(21) (22)	0.64 0.01	0.89 0.16	0.88 0.16	0.86 0.15	0.89 0.14	55	(16) (17)	0.23 5.0	0.23 5.0	0.23 5.0	0.20 5.0	0.23 5.0
(23) (24)	0.52 0.03	0.72 0.03	0.72 0.03	0.69 0.03	0.73 0.03		(18) (19)	4.40 10.74	4.37 8.43	5.34 8.41	4.33 8.41	6.79 8.39
(25) (26)	0.64 2.57	0.54 1.78	0.54 1.81	0.54 1.83	0.53 1.83		(20) (21)	2.54 0.89	2.49 1.61	2.31 2.27	2.45 2.76	2.47 0.82
(27)	0.13	0.03	0.03	0.08	0.03		(22)	0.13	0.12	0.09	0.17	0.08
(28) (29)	1.06 0.94	0.27 0.43	0.31 0.42	0.75 0.37	0.24 0.39	60	(23) (24)	0.73 0.03	0.73 0.03	0.73 0.03	0.73 0.03	0.73 0.03
(30) (31)	0.06 0.77	0.26 0.61	0.37 0.62	0.38 0.69	0.37 0.61		(25) (26)	0.52 1.78	0.51 1.75	0.48 1.65	0.48 1.50	0.53 1.80
(32)	0.83	0.63	0.65	0.72	0.63		(27)	0.03	0.04	0.04	0.04	0.04
(33) (34)	1.97 2.86	1.15 2.04	1.16 2.05	1.10 2.02	1.11 2.03	65	(28) (29)	0.30 0.40	0.38 0.35	0.38 0.16	0.38 0.16	0.38 0.25
(35)	7.17	8.17	9.29	9.68	9.74		(30)	0.37	0.32	0.33	0.35	0.66

		20) <u>Z</u>		
		-cont	inued						-cont	inued		
(31)	0.59	0.55	0.47	0.44	0.63		(26)	2.01	2.11	2.50	2.22	2.04
(32)	0.60	0.57	0.50	0.47	0.65		(27)	0.33	0.27	0.07	0.04	0.08
(33)	1.03	1.10	1.10	1.02	1.05	_	(28)	2.82	2.52	0.58	0.39	0.69
(34)	2.00	2.05	2.18	2.23	2.06	5	(29)	0.20	0.29	0.86	0.61	0.85
(35)	8.38	7.21	5.10	4.92	9.56		(30)	0.12	0.12	0.13	0.21	0.05
(36)	0.14	0.15	0.20	0.20	0.12		(31)	0.90	0.99	0.80	0.51	0.38
(37) (38)	1.74 2.05	1.72 2.30	1.96 4.74	1.96 4.49	1.81 3.37		(32) (33)	0.94 1.44	1.02 1.49	0.89 2.25	0.55 1.53	0.40 1.36
(39)	22.06	9.97	9.04	8.98	10.58		(34)	2.64	2.47	2.23	2.85	3.07
(40)	9.42	7.85	5.84	5.69	4.88	10	(35)	5.50	6.93	10.06	6.49	3.36
(41)	1.20	1.15	1.09	1.04	1.24		(36)	0.35	0.28	0.19	0.15	0.23
(42)	0.03	0.03	0.03	0.03	0.03		(37)	1.60	1.73	12.47	9.82	4.78
(43)	0.03	0.03	0.03	0.03	0.03 1.00		(38)	2.26 13.33	1.62	0.77	0.93	0.63
(45) (47)	1.00 0.67	1.00 0.66	1.00 0.65	1.00 0.62	0.65		(39) (40)	13.33	1.18 13.77	8.21 6.80	10.05 26.71	2.92 59.95
(49)						15	(41)	1.60	1.60	10.30	6.18	3.14
(51)	0.05	0.05	0.06	0.06	0.08	13	(42)	0.03	0.03	0.03	0.02	0.03
(53)	0.06	0.05	0.05	0.04	0.09		(43)	0.02	0.02	0.02	0.02	0.02
(54)	0.95	0.94	0.94	0.94	0.94		(45)	1.00	1.00	1.00	1.00	0.45
(55)	0.53	0.52	0.50	0.49	0.54		(47)	0.68	0.68	_	0.77	0.26
(56) (57)	1.48 -2.19	1.32 -1.24	1.32 -1.09	1.32 -1.05	1.32 -1.21		(49) (51)	0.03	0.03	0.04	0.05	0.03
(37)	-2.17	-1.24	-1.02	-1.03	-1.21	20	(53)	0.03	0.03	0.01	0.03	0.03
	Exam-	Exam-	Exam-	Exam-	Exam-		(54)	0.61	0.65	0.89	0.94	0.90
	ple48	ple49	ple50	ple51	ple52		(55)	0.40	0.42	0.37	0.38	0.34
·						-	(56)	0.64	0.69	1.37	1.53	1.10
(15)	-1.33	-1.33 0.20	-1.40	-1.33 0.20	-1.40		(57)	1.77	1.47	-1.70	-2.25	0.33
(16) (17)	0.20 5.0	5.0	0.17 5.8	5.7	0.17 5.9	25		Exam-	Exam-	Exam-	Exam-	Exam-
(18)	7.70	7.79	1.61	3.08	1.10			ple58	ple59	ple60	ple61	ple62
(19)	8.50	8.49	3.05	2.84	2.57	_					1	1
(20)	2.37	2.12	2.29	2.18	2.23		(15)	-1.33	-1.33	-1.33	-3.57	-3.56
(21)	1.45	1.67	0.97	0.47	0.79		(16)	0.23	0.23	0.23	0.60	0.60
(22)	0.06	0.10	0.36	0.28	0.33 0.51	30	(17)	5.5	5.6	5.6	5.5	5.5
(23) (24)	0.72 0.03	0.72 0.03	0.52 0.03	0.52 0.03	0.51	30	(18)	8.68	-0.12	1.62	4.121	2.714
(25)	0.55	0.57	0.61	0.63	0.61		(19)	7.46	7.70	8.43	0.12	0.14
(26)	1.65	1.65	2.10	2.31	2.11		(20)	2.18	2.19	1.98	0.57	0.58
(27)	0.04	0.04	0.22	0.24	0.27		(21) (22)	0.82 0.14	0.75 0.03	0.79 0.03	0.80 0.01	0.79 0.01
(28)	0.38	0.38	2.11	2.21	2.52		(23)	0.60	0.60	0.61	0.84	0.84
(29)	0.00	-0.02	0.28	0.35	0.29	35	(24)	0.03	0.03	0.03	0.030	0.030
(30)	1.45 0.66	1.67 0.75	0.13 0.89	0.12 1.05	0.12 0.99		(25)	0.59	0.58	0.58	0.31	0.31
(31) (32)	0.00	0.73	0.89	1.03	1.02		(26)	2.61	2.57	2.51	1.30	1.32
(33)	1.15	1.35	1.44	1.67	1.49		(27)	0.08	0.08	0.07	0.17	0.16
(34)	2.32	2.39	2.53	2.43	2.47		(28)	0.81	0.79	0.72	1.59	1.53
(35)	9.80	10.26	6.96	7.76	6.93	40	(29)	0.83	0.86	0.60	-0.67	-0.69
(36)	0.12	0.12	0.28	0.26	0.28		(30)	0.26	0.16	0.11	0.21	0.20
(37)	2.31	2.62	1.80	1.99	1.73		(31)	0.63	0.59	0.54	0.51	0.50
(38) (39)	-2459.34 16.97	-47.39 -272.93	1.66 1.12	1.56 1.73	1.62 1.18		(32)	0.67	0.62	0.59	0.53	0.53
(40)	2.48	2.43	13.27	9.52	13.77		(33)	1.64 2.71	1.60	1.51 2.77	0.77	0.78
(41)	1.35	1.30	1.62	1.68	1.60		(34) (35)	8.99	2.66 7.42	6.89	1.13 3.20	1.13 3.18
(42)	0.03	0.03	0.03	0.03	0.03	45	(36)	0.15	0.18	0.19	0.41	0.40
(43)	0.03	0.03	0.02	0.02	0.02		(37)	3.32	3.00	3.04	-2.51	-2.50
(45)	1.00	1.00	1.00	1.00	1.00		(38)	0.78	0.74	1.04	-5.56	-5.20
(47) (49)	0.59	0.55	0.68	0.64	0.68		(39)	6.02	2.79	4.50	0.31	0.32
(51)	0.14	0.17	0.03	0.03	0.03		(40)	6.92	16.02	7.56	9.68	10.43
(53)	0.17	0.22	0.03	0.02	0.02	50	(41)	1.79	1.97	1.70	-2.20	-2.16
(54)	0.94	0.93	0.70	0.66	0.65		(42)	0.03	0.03	0.03	0.03	0.03
(55)	0.55	0.57	0.41	0.43	0.42		(43)	0.02	0.02	0.02	0.03	0.03
(56)	1.32	1.32	0.74	0.72	0.69		(45)	1.00	1.00	0.39	0.74	0.75
(57)	-0.99	-0.92	1.34	1.33	1.47	_	(47) (49)	0.66 0.83	0.73 0.26	0.68	0.44	0.45
	Exam-	Exam-	Exam-	Exam-	Exam-	- 55	(51)	0.83	0.28	0.04	0.08	0.07
	ple53	ple54	ple55	ple56	ple57	33	(51)	0.03	0.03	0.04	0.08	0.07
	piess	P.55	P.000	P1000	Pros.	_	(54)	0.88	0.89	0.90	0.79	0.80
(15)	-1.40	-1.40	-1.10	-1.56	-1.60		(55)	0.40	0.40	0.39	0.70	0.70
(16)	0.17	0.17	0.23	0.20	0.20		(56)	1.12	1.14	1.20	0.85	0.85
(17)	5.7	5.9	4.6	4.6	4.7		(57)	-0.19	-0.34	-0.51	1.08	1.08
(18)	1.55	1.10	16.84	-0.34	-4.26	60 –						
(19)	2.24	2.57	11.88	13.08	7.02			Exam-	Exam-	Exam-	Exam-	Exam-
(20)	2.20	2.23	2.77	2.20	1.94			ple63	ple64	ple65	ple66	ple67
(21)	0.80	0.79	0.31	1.01	0.98	_	(4.5)	3.55	2.54	2.50	3.5.5	3.55
(22)	0.28	0.33	0.03	0.10	0.14		(15)	-3.56	-3.56	-3.56	-3.56	-3.55
(23) (24)	0.48 0.03	0.51 0.03	0.53 0.03	0.62 0.02	0.61 0.03	65	(16) (17)	0.60 6.2	0.60 6.1	0.60 5.8	0.60 5.9	0.60 5.5
(24)	0.03	0.03	0.68	0.02	0.03	00	(17)	2.887	3.456	5.8 1.820	3.9 2.639	3.3 4.128
(23)	0.55	0.01	0.00	0.01	0.01		(10)	2.007	5.750	1.020	2.037	1.120

		-cor	ntinued						-cont	inued		
(19) (20) (21)	0.16 0.53 1.85	0.15 0.51 1.84	0.13 0.55 0.80	0.19 0.58 0.80	0.14 0.58 0.78			Exam- ple73	Exam- ple74	Exam- ple75	Exam- ple76	Exam- ple77
(21)	0.01	0.01	0.01	0.01	0.78	5	(15)	-3.54	-1.33	-1.33	-1.34	-1.34
(23)	0.89	0.90	0.85	0.86	0.84		(16)	0.80	0.23	0.23	0.23	0.22
(24)	0.030	0.030	0.030	0.030	0.030		(17)	6.4	4.0	3.3	3.7	3.7
(25) (26)	0.29 1.32	0.29 1.27	0.32 1.33	0.31 1.49	0.31 1.32		(18) (19)	14.496 0.38	5.058 0.98	9.279 2.77	1.986 1.02	2.892 0.89
(27)	0.10	0.09	0.15	0.14	0.16		(20)	0.37	1.52	1.91	1.78	1.79
(28)	1.16	1.06	1.53	1.47	1.55	10		0.51	1.13	1.29	1.49	1.03
(29)	-0.50	-0.46	-0.66	-0.65	-0.69		(22)	0.01	0.44	0.26	0.36	0.35
(30) (31)	0.18 0.44	0.19 0.43	0.23 0.51	0.18 0.48	0.22 0.49		(23) (24)	0.95 0.030	0.87 0.030	0.89 0.030	0.85 0.030	0.86 0.030
(32)	0.44	0.45	0.54	0.50	0.52		(25)	0.32	0.030	0.030	0.030	0.030
(33)	0.78	0.76	0.82	0.86	0.78		(26)	1.66	1.08	1.18	1.10	1.08
(34)	1.11	1.10	1.13	1.14	1.14	15	(27)	0.04	0.07	0.03	0.09	0.09
(35)	3.26	3.07	3.81	3.20	3.22		(28)	0.46	0.55	0.21	0.60	0.58
(36) (37)	0.32 -5.18	0.31 -6.53	0.32 -2.68	0.36 -3.08	0.41 -2.46		(29) (30)	-0.17 0.00	-1.58 0.60	-1.05 0.58	-1.85 0.48	-1.45 0.66
(38)	-7.97	-9.78	-5.56	-4.54	-5.14		(31)	0.47	0.70	0.49	0.66	0.74
(39)	0.45	0.48	0.34	0.38	0.32		(32)	0.47	0.84	0.60	0.77	0.89
(40)	12.25	11.51	9.32	12.61	9.00	20	(33)	0.74	1.14	1.01	1.16	1.18
(41) (42)	-3.88 0.03	-4.55 0.03	-2.24 0.03	-2.35 0.03	-2.12 0.03		(34) (35)	1.05 6.37	1.41 4.25	1.53 3.26	1.41 3.76	1.43 4.20
(42)	0.03	0.03	0.03	0.03	0.03		(36)	0.10	0.21	0.20	0.21	0.21
(45)	0.70	0.69	0.75	0.75	0.75		(37)	-17.56	-2.28	-3.95	-3.14	-2.82
(47)	_	_	0.44	0.44	0.44		(38)	-31.36	-1.92	-2.96	-1.44	-2.15
(49)	0.07	0.07	0.09	0.07	0.08	25	(39)	3.03	7.87 2.94	23.82	8.76	5.83
(51) (53)	0.07	0.07	0.09	0.07	0.08		(40) (41)	-9696.32 -5.11	-0.58	22.27 -0.65	3.84 -0.76	3.10 -0.85
(54)	0.87	0.88	0.81	0.83	0.80		(42)	0.03	0.03	0.03	0.03	0.03
(55)	0.67	0.65	0.71	0.69	0.70		(43)	0.03	0.03	0.03	0.03	0.03
(56)	0.90	0.91	0.86	0.87	0.85		(45)	0.35	0.83	0.86	0.88	0.86
(57)	1.04	1.04	1.08	1.06	1.09	30	(47) (49)	0.97 —	0.36	_	0.40	0.37
	Exam-	Exam-	Exam-	Exam-	Exam-		(51)	0.02	0.17	0.18	0.15	0.19
	ple68	ple69	ple70	ple71	ple72		(53) (54)	0.13 0.95	0.03 0.88	0.03 0.95	0.03 0.86	0.04 0.86
(15)	-3.51	-3.51	-3.55	-3.53	-3.56	-	(55)	0.80	0.72	0.69	0.73	0.74
(15) (16)	0.60	0.59	0.62	0.60	0.81		(56)	0.98	0.94	1.09	0.92	0.92
(17)	4.7	4.0	4.3	4.2	20.0	35	(57)	0.90	1.03	0.45	1.02	1.08
(18)	5.676	-2.165	2.520	-4.024	16.232			Exam-	Exam-	Exam-	Exam-	Exam-
(19)	0.43	0.44	0.41	0.43	0.06			ple78	ple79	ple80	ple81	ple82
(20)	0.47	0.59	0.55	0.56	0.15							
(21) (22)	0.53 0.03	0.68 0.04	0.72 0.07	0.70 0.13	1.29 0.03		(15)	-1.33	-2.20	-2.00	-2.00	-2.00
(22)	0.03	0.04	0.07	0.13	0.03	40	(16) (17)	0.23 3.8	0.38 5.5	0.32 5.1	0.32 5.1	0.32 5.1
(24)	0.030	0.030	0.030	0.030	0.030		(18)	2.970	7.326	5.550	6.867	6.856
(25)	0.34	0.34	0.30	0.32	0.26		(19)	0.92	6.01	1.47	0.89	0.89
(26)	1.13	1.21	1.23	1.22	1.60		(20)	1.77	1.51	1.28	1.29	1.26
(27)	0.02	0.04	0.04	0.04	0.06		(21) (22)	0.98 0.29	0.73 0.01	$\frac{1.07}{0.11}$	1.14 0.10	1.30 0.06
(28)	0.20	0.30	0.30	0.30	2.37	45	(23)	0.87	0.74	0.90	0.87	0.87
(29) (30)	-0.21 0.06	-0.25 0.09	-0.15 0.04	-0.23 0.02	-0.20 0.15		(24)	0.030	0.030	0.030	0.030	0.030
(31)	0.49	0.47	0.42	0.45	0.37		(25)	0.46	0.46	0.39	0.40	0.38
(32)	0.52	0.52	0.43	0.48	0.38		(26)	1.08	3.74	1.22	1.24	1.24
(33)	0.80	0.84	0.69	0.73	0.80		(27) (28)	0.08 0.55	0.05 0.53	0.05 0.44	0.08 0.72	0.08 0.72
(34)	1.09	1.14	1.07	1.10	1.05	50	(29)	-1.52	0.57	-1.18	-0.96	-0.96
(35)	4.29	3.54	3.75	3.97	9.28		(30)	0.64	0.08	0.54	0.54	0.55
(36) (37)	0.19 -3.19	0.20 -3.97	0.24 -5.93	0.23 -4.70	0.31 -15.07		(31)	0.71	0.44	0.54	0.62	0.55
(38)	-36.12	-20.98	-3.93 -38.61	-4.70 -23.70	-31.38		(32) (33)	0.85 1.14	0.46 1.27	0.57 0.83	0.65 0.87	0.59 0.80
(39)	12.39	4.04	-43.59	-17.45	0.60		(34)	1.40	2.07	1.31	1.28	1.32
(40)	-32.00	29.54	3950.63	82.32	41.33	55	(35)	4.06	5.31	4.96	4.82	4.44
(41)	-0.90	-1.09	-1.81	-1.34	-11.72		(36)	0.21	0.16	0.23	0.23	0.23
(42)	0.03	0.03	0.03	0.03	0.03		(37)	-2.67	3.89	-13.18	-8.91	-93.62
(43)	0.03	0.03	0.03	0.03	0.03		(38)	-2.12	1.86	-1.60	-2.00	-2.00
(45)	0.50	0.47 0.90	0.43	0.45	0.64		(39)	6.61 3.10	-1270.10 30.48	23.23 4.24	4.39 4.27	3.92
(47) (49)	0.86	0.90	0.96 —	0.94	_	60	(40) (41)	-0.80	1.39	-6.32	4.27 -5.14	3.86 -49.35
(51)	0.14	0.09	0.04	0.06	0.05	00	(42)	0.03	0.03	0.03	0.03	0.03
(53)	0.14	0.08	0.16	0.11	0.02		(43)	0.03	0.02	0.03	0.03	0.03
(54)	0.97	0.94	0.95	0.95	0.92		(45)	0.85	1.00	0.83	0.82	0.80
(55)	0.82	0.76	0.76	0.77	0.63		(47)	0.38	0.72	0.46	0.48	0.46
(56)	1.00	0.98	0.98	0.98	0.94		(49)	_	_	_	_	_
(57)	0.92	0.97	0.92	0.93	1.03	65 -	(51) (53)	0.19 0.05	0.05 0.02	0.13 0.06	0.11 0.07	0.13 0.07
						-	(22)	0.05	0.02	0.00	0.07	0.07

					\cup 5 9,	131	,93/B2	<u> </u>				
			65 tinued						266			
(54) (55) (56) (57)	0.88 0.74 0.94 1.04	0.93 0.51 1.16 -0.28	0.93 0.70 1.00 0.74	0.89 0.70 0.94 0.93	0.89 0.68 0.94 0.97	- 5	(45) (47) (49) (51)	0.82 — — 0.08	0.80 — — — 0.06	0.58 0.88 — 0.10	0.62 0.88 — 0.10	0.64 0.87 — 0.13
	Exam- ple83	Exam- ple84	Exam- ple85	Exam- ple86	Exam- ple87	-	(53) (54) (55)	0.02 0.83 0.76	0.02 0.63 0.79	0.02 0.66 0.67	0.02 0.67 0.66	0.01 0.92 0.75
(15) (16)	-1.32 0.33	-2.54 0.42	-2.58 0.40	-1.99 0.40	-4.18 0.74	- 10	(56) (57)	0.87 1.04	0.71 1.02	0.90 0.98	0.91 0.98	0.95 1.09
(17) (18) (19)	4.1 9.402 3.16	4.4 21.517 0.58	5.5 3.391 1.03	6.4 2.859 1.19	8.8 8.190 0.11			Exam- ple93	Exam- ple94		am- e95	Exam- ple96
(20) (21)	1.25 1.19	1.45 0.74	1.36 1.11	1.29 0.80	0.42 0.59		(15) (16)	-2.04 0.40	-4.09 0.69	(2.00 0.32	-2.00 0.32
(22) (23) (24)	0.39 0.91 0.030	0.09 0.67 0.021	0.01 0.80 0.030	0.01 0.79 0.030	0.03 0.84 0.030	15	(17) (18) (19)	11.8 8.840 0.86	17.8 14.080 0.20	1	5.2 1.990 1.18	5.2 0.995 1.17
(25) (26) (27)	0.49 1.07 0.02	0.40 2.82 0.32	0.32 2.13 0.12	0.35 1.96 0.12	0.25 2.00 0.17		(20) (21) (22)	0.82 0.60 0.55	0.37 2.33 0.45	().94).85).50	0.91 0.73 0.35
(28) (29)	0.18 -2.12	2.12 1.14	1.23 -0.86	1.35 -1.51	2.52 -0.56	20	(23) (24)	0.85 0.032	0.92 0.030	().91).030	0.91 0.030
(30) (31) (32)	0.45 0.74 0.85	0.19 0.56 0.71	0.27 0.36 0.37	0.26 0.41 0.43	0.11 0.37 0.38		(25) (26) (27)	0.44 2.38 0.10	0.31 2.64 0.07]).33 1.27).04	0.36 1.26 0.04
(33) (34) (35)	1.09 1.37 5.65	0.95 1.74 23.80	0.76 1.57 4.49	0.85 1.57 4.50	0.71 1.11 17.87	25	(28) (29) (30)	2.07 -0.52 0.30	2.28 -0.29 0.44	-().44).70).21	0.44 -0.70 0.20
(36) (37)	0.22 -4.40	0.06 1.03	0.34 -3.39	0.42 -1.68	0.05 -8.39		(31) (32)	0.72 0.79	0.44 0.49	().47).45	0.53 0.51
(38) (39) (40)	-1.31 55.20 4.99	1.58 0.30 0.77	-1.53 0.79 12.26	-0.81 0.77 17.99	-5.89 0.26 49.15		(33) (34) (35)	1.33 1.31 23.83	0.97 1.17 -6.82	1	0.70 1.18 9.42	0.74 1.16 9.76
(41) (42) (43)	-1.49 0.03 0.03	1.19 0.02 0.02	-4.03 0.03 0.03	-1.67 0.03 0.03	-6.31 0.03 0.03	30	(36) (37) (38)	0.18 -0.62 -2.51	0.00 2.01 -10.00	7	0.05 7.72 3.48	0.05 11.52 -3.50
(45) (47)	0.90 0.42	0.27	0.83	0.88	0.79		(39) (40)	1.92 4.90	0.98 2.78	24 -105	4.77 5.70	-4293.76 -105.84
(49) (51) (53)	0.14 0.04	0.21 0.09	0.09 0.04	0.09 0.05	0.08 0.03	35	(43)	-0.68 0.03 0.03	2.46 0.03 0.03	(3.35 0.03 0.03	4.88 0.03 0.03
(54) (55) (56)	0.96 0.78 1.13	0.65 0.69 0.71	0.85 0.56 0.87	0.86 0.60 0.88	0.81 0.74 0.85		(45) (47) (49)	0.61 0.88 —	0.64 — —		0.81 0.31 —	0.83 0.29 —
(57)	0.13	1.52	1.17	1.10	1.06	- 40	(51) (53)	0.10 0.02	0.12 0.03	(0.06	0.05 0.07
	Exam- ple88	Exam- ple89	Exam- ple90	Exam- ple91	Exam- ple92	_	(54) (55) (56)	0.67 0.65 0.91	0.91 0.96 0.94	().94).86).99	0.94 0.87 0.99
(15) (16) (17)	-4.18 0.75 6.7	-8.37 0.95 11.5	-2.04 0.39 9.8	-2.04 0.41 11.8	-4.09 0.74 17.8		(57)	0.97	1.09	(0.72	0.70
(18) (19)	7.905 0.17	17.163 0.01	10.582 0.81	9.821 0.86	16.263 0.21	45	More					ple are give the first len
(20) (21) (22)	0.47 0.65 0.01	0.20 0.44 0.01	0.89 0.60 0.41	0.83 0.59 0.49	0.37 1.95 0.01		unit, N_{G}	denotes nu	mber of lens	es in the	second	Hens unit, f_{G2i} denotes
(23) (24) (25)	0.86 0.030 0.27	0.70 0.030 0.21	0.85 0.032 0.46	0.85 0.032 0.44	0.93 0.030 0.32	50	focal len	gth of the se	econd image	e-side le	ns. Fur	thermore, f

0.21

2.76

0.41

6.72

-0.29

0.06

0.42

0.42

0.74

1.03

0.00

0.10

-71.88

-25.04

1016.39

-53.92

0.03

0.03

-8.15

0.27

1.92

0.14

1.67

-0.77

0.03

0.41

0.42

0.83

1.11

6.98

0.08

-8.54

-4.16

0.36

150.63

-4.92

0.03

0.03

(26)

(27)

(28)

(29)

(30)

(31)

(32)

(33)

(34)

(35)

(36)

(37)

(38)

(39)

(40)

(41)

(42)

(43)

0.46

2.02

0.10

1.76

-0.56

0.33

0.79

0.87

1.36

1.29

10.00

0.41

-0.53

-2.50

3.60

4.03

-0.58

0.03

0.03

0.44

2.44

0.10

2.07

-0.54

0.30

0.71

0.78

1.34

1.31

26.35

0.16

-0.60

-2.50

1.81

4.75

-0.69

0.03

0.03

0.32

2.80

0.06

2.07

-0.31

0.32

0.43

0.49

1.11

1.17

0.00

-2.01

-10.00

1.07

2.77

-2.18

0.03

0.03

-13.67

en ens $_{50}$ $\,$ focal length of the second image-side lens. Furthermore, $\rm f_{\it L1}$ to F_{L19} denotes a focal length of each lens, and correspond to L1 to L19 shown in the cross-sectional view of the optical system. Also, with respect to the example which includes a diffraction optical element, description for focal length of a 55 lens, shown by DL in the cross-sectional view of the optical system, is omitted.

		Example8	Example9	Example10	Example11
60	D_{oi}	60.0	57.9	60.0	60.0
	Y _{obj} Y	4.7	4.7	4.8	4.8
	Y	4.92	4.92	4.92	4.92
	L_{TL}	35.02	40.92	35.01	35.01
	L_L	30.71	36.61	30.70	30.70
	WD	25.00	17.00	25.00	25.00
65	BF	4.31	4.31	4.31	4.31
	NA	0.15	0.21	0.15	0.15

		-continued					-continued		
β	-1.04	-1.05	-1.03	-1.03	Y	4.92	4.92	4.92	4.92
f	9.34	9.35	9.35	10.22	L_{TL}	43.01	40.23	35.01	42.41
Φ_{G1o}	12.87	15.15	13.09	13.55	$_{\varepsilon}$ L_{L}	38.70	35.92	30.70	40.53
Φ_s	4.84	5.70	4.73	4.77	WD	17.00	19.78	25.00	27.58
D_{os}	38.52	35.88	38.53	38.18	BF	4.31	4.31	4.31	1.88
D_{G1G2}	1.87	2.17	1.77	1.40	NA o	0.18	0.20	0.15	0.15
L_{G1}	12.37	17.71	12.51	12.20	β f	-1.05	-1.05	-1.04	-1.00
L _{G2}	16.47 5.01	16.73 3.02	16.42 4.85	17.10 4.57		10.48 12.75	10.21 14.20	8.63 12.86	9.02 14.58
$CRA_{obj}(MAX)$ $CRA_{obj}(MIN)$	0.00	0.00	0.00	0.00	φ _{G10} 10 φ _s	4.52	5.67	5.89	5.59
CRA _{img}	20.40	23.21	20.47	20.41	\mathcal{D}_{os}	32.54	33.57	38.03	45.84
D_{max}	5.72	5.24	5.70	4.65	D_{G1G2}	1.68	2.34	3.56	1.37
D_{G1max}	1.23	2.49	0.99	1.10	L_{G1}	14.57	12.53	9.67	16.92
vd _{max}	81.61	81.61	81.61	81.61	L_{G2}	22.44	21.05	17.47	22.24
vd_{min}	30.30	30.30	30.30	31.32	$CRA_{obj}(MAX)$	4.97	5.01	5.00	4.01
N_{G1}	4.00	5.00	4.00	4.00	15 CRA _{obj} (MIN)	0.00	0.00	0.00	0.00
N_{G2}	5.00	5.00	6.00	6.00	CRA_{img}	18.67	18.43	22.74	21.84
f_{G1}	13.85	12.59	14.04	13.02	D_{max}	5.88	5.84	3.56	4.34
f_{G2}	53.90	19.64	34.90	39.91	D_{G1max}	0.10	1.38	0.10	2.78
f _{G10}	24.63 -10.50	23.26 -8.84	23.74 -10.57	21.53 -10.74	vd _{max}	81.61 23.77	81.61 30.30	81.61 33.79	81.61 30.30
$egin{aligned} &\mathbf{f}_{G2i}\ &\mathbf{f}_{L1} \end{aligned}$	24.63	23.26	23.74	21.53	vd_{min} N_{G1}	5.00	4.00	4.00	7.00
\mathbf{f}_{L2}	27.02	-40.17	27.43	24.93	$ \begin{array}{ccc} N_{G1} \\ N_{G2} \end{array} $	5.00	5.00	6.00	7.00
f_{L3}	12.38	18.64	10.99	13.31	f_{G1}	12.37	13.75	17.15	14.57
f_{L4}	-6.99	9.77	-6.17	-6.78	f_{G2}	13.91	16.65	35.67	-25.41
f_{L5}	-15.63	-6.61	-16.62	-25.51	f_{G1o}	54.82	24.83	21.39	68.99
f_{L6}	51.27	-14.37	44.82	33.89	f_{G2i}	-10.13	-12.05	-12.01	-13.57
f_{L7}	20.88	73.73	11.13	20.46	f_{L1}	54.82	24.83	21.39	24.92
f_{L8}	15.49	12.37	-12.69	8.23	23 f _{L2}	27.79	27.96	22.33	34.57
f_{L9}	-10.50	22.47	11.28	-12.22	f_{L3}	21.01	11.33	15.76	15.04
f_{L10}	_	-8.84	-10.57	-10.74	f_{L4}	8.55	-6.47	-7.77	-10.67
	E	EI-12	EI-14	D1-15	f_{L5}	-4.58	-17.53	-11.67	-9.30
	Example12	Example13	Example14	Example15	f_{L6}	-8.88 16.30	38.34 14.48	9.71 12.02	18.19 25.65
D_{oi}	55.0	55.0	60.0	60.0	f _{L7} 30 f _{z0}	14.63	48.32	28.79	145.05
\mathbf{Y}_{obj}	4.7	4.7	4.7	4.7	f_{L8} f_{L9}	24.09	-12.05	-14.54	13.70
Y	4.92	4.92	4.92	4.92	f_{L10}	-10.13	_	-12.01	-19.71
L_{TL}	35.01	34.01	36.00	44.05	f_{L11}	_	_	_	-13.57
L_L	32.11	31.12	32.87	40.74					
$_{ m WD}^{ m L_{\it L}}$	32.11 20.00	31.12 21.00	32.87 24.00	40.74 15.97		Example20	Example21	Example22	Example23
WD BF	20.00 2.90	21.00 2.89	24.00 3.13	15.97 3.31	35	-			
WD BF NA	20.00 2.90 0.18	21.00 2.89 0.13	24.00 3.13 0.14	15.97 3.31 0.21	D_{oi}	50.5	90.0	74.0	75.0
WD BF NA β	20.00 2.90 0.18 -1.05	21.00 2.89 0.13 -1.05	24.00 3.13 0.14 -1.05	15.97 3.31 0.21 -1.05	$ \begin{array}{c} $	50.5	90.0	74.0 3.7	75.0 3.7
WD BF NA β f	20.00 2.90 0.18 -1.05 7.99	21.00 2.89 0.13 -1.05 8.59	24.00 3.13 0.14 -1.05 9.49	15.97 3.31 0.21 -1.05 8.84	$ \begin{array}{c} $	50.5 3.7 4.92	90.0 3.7 4.92	74.0 3.7 4.92	75.0 3.7 4.92
WD BF NA β f Φ _{G1o}	20.00 2.90 0.18 -1.05 7.99 13.29	21.00 2.89 0.13 -1.05 8.59 11.27	24.00 3.13 0.14 -1.05 9.49 12.33	15.97 3.31 0.21 -1.05 8.84 13.69	$ \begin{array}{c} & \\ & \\ & \\ & \\ & \\ & \\ & \\ & $	50.5 3.7 4.92 36.73	90.0 3.7 4.92 60.00	74.0 3.7 4.92 44.01	75.0 3.7 4.92 45.00
WD BF NA β f ϕ_{G1o} ϕ_s	20.00 2.90 0.18 -1.05 7.99 13.29 5.73	21.00 2.89 0.13 -1.05 8.59 11.27 3.56	24.00 3.13 0.14 -1.05 9.49 12.33 4.32	15.97 3.31 0.21 -1.05 8.84 13.69 6.29	$ \begin{array}{c} & D_{oi} \\ & Y_{obj} \\ & Y \\ & L_{IL} \\ & L_{L} \end{array} $	50.5 3.7 4.92 36.73 34.85	90.0 3.7 4.92 60.00 58.09	74.0 3.7 4.92 44.01 42.57	75.0 3.7 4.92 45.00 42.76
WD BF NA β f ϕ_{G1o} ϕ_s D_{os}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22	35 $\begin{array}{c} D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ 40 \end{array}$	50.5 3.7 4.92 36.73 34.85 13.80	90.0 3.7 4.92 60.00 58.09 30.00	74.0 3.7 4.92 44.01 42.57 30.00	75.0 3.7 4.92 45.00 42.76 30.00
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73	21.00 2.89 0.13 -1.05 8.59 11.27 3.56	24.00 3.13 0.14 -1.05 9.49 12.33 4.32	15.97 3.31 0.21 -1.05 8.84 13.69 6.29	$ \begin{array}{c} & D_{oi} \\ & Y_{obj} \\ & Y \\ & L_{IL} \\ & L_{L} \end{array} $	50.5 3.7 4.92 36.73 34.85	90.0 3.7 4.92 60.00 58.09	74.0 3.7 4.92 44.01 42.57 30.00 1.44	75.0 3.7 4.92 45.00 42.76
WD BF NA β f ϕ_{G1o} ϕ_s D_{os}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13	$ \begin{array}{c} & D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ 40 \\ BF \end{array} $	50.5 3.7 4.92 36.73 34.85 13.80 1.88	90.0 3.7 4.92 60.00 58.09 30.00 1.91	74.0 3.7 4.92 44.01 42.57 30.00	75.0 3.7 4.92 45.00 42.76 30.00 2.25
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70	$ \begin{array}{c} & D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ 40 \\ BF \\ NA \end{array} $	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN)	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 5.01 0.00	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00	35 $\frac{D_{oi}}{Y_{obj}}$ Y L_{IL} L_{L} VWD BF NA β	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} $CRA_{obj}(MAX)$ $CRA_{obj}(MIN)$ CRA_{jino}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11	35 $ \frac{D_{oi}}{Y_{obj}} $ $ Y \\ Y \\ L_{TL} $ $ L_{L} $ WD $ BF $ NA $ \beta $ f $ \phi_{G1o} $ $ \phi_{s}$	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{img} D_{max}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13	$ \begin{array}{c} & D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \\ L_{L} \\ 40 & \text{WD} \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \end{array} $	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{img} D_{max} D_{G1max}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15	35 $ \begin{array}{c} D_{oi} \\ Y_{obj} \\ Y \\ L_{IL} \\ L_{L} \end{array} $ 40 $ \begin{array}{c} WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \end{array} $	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN) CRA_{img} D_{max} Vd_{max}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61	35 Doi Yobj Y L. L. L. L. WD BF NA β f φ _{G1o} φ _s D _{G1G2} L _{G1}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{o1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{bing} D_{max} D_{G1max} vd_{min}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77	35 $ \frac{D_{oi}}{Y_{obj}} $ Y $ L_{TL} $ $ L_{L} $ WD $ BF $ NA $ \beta $ f $ \phi_{G1o} $ $ \phi_{s} $ $ D_{os} $ $ D_{G1G2} $ $ L_{G1} $ $ L_{G2} $	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN) CRA_{img} D_{max} D_{G1max} vd_{max} vd_{min} N_{G1}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00	35 Doi Yobj Y LTL LL 40 WD BF NA β f ΦG1o 45 Dos DG1G2 LG1 LG2 CRAobj (MAX) CRA LG (MIN)	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{o1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{bing} D_{max} D_{G1max} vd_{min}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77	35 Doi Yobj Y LTL LL 40 WD BF NA β f ΦG1o 45 Dos DG1G2 LG1 LG2 CRAobj (MAX) CRA LG (MIN)	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN) CRA_{img} D_{max} D_{G1max} vd_{max} vd_{min} N_{G1} N_{G2} f_{G1}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00	35 Doi Yobj Y LTL LL 40 WD BF NA β f ΦG1o 45 Dos DG1G2 LG1 LG2 CRAobj (MAX) CRAobj (MIN) 50 CRAmg	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00
WD BF NA β f ϕ_{G1o} ϕ_s Dos Dos D $_{G1G2}$ L $_{G1}$ L $_{G2}$ CRA $_{obj}$ (MAX) CRA $_{obj}$ (MIN) CRA $_{img}$ D $_{max}$ Vd $_{max}$ Vd $_{min}$ N $_{G1}$ N $_{G2}$ f $_{G1}$ f $_{G2}$	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91	35 $\frac{D_{oi}}{Y_{obj}}$ Y L_{TL} L_{L} 40 WD BF NA β f ϕ_{G1o} 45 $\frac{\Phi_{G1o}}{D_{os}}$ D_{G1G2} L_{G1} L_{G2} $CRA_{obj}(MIN)$ 50 CRA_{img} D_{max}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{os} D_{G1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN) CRA_{img} D_{max} D_{G1max} vd_{max} vd_{min} N_{G1} N_{G2} f_{G1}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21	35 Doi Yobj Y LTL LL 40 WD BF NA β f ΦG1o 45 Dos DG1G2 LG1 LG2 CRAobj (MAX) CRAobj (MIN) 50 CRAmg	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61
WD BF NA β f ϕ_{G1o} ϕ_s Dos	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21	35 $ \begin{array}{c} D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \end{array} $ 40 $ \begin{array}{c} WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \Phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) $ 50 $ \begin{array}{c} CRA_{obj} (MIN) \\ CRA_{obj} (MIN) \end{array} $ 50 $ \begin{array}{c} CRA_{obj} (MIN) \\ CRA_{obj} (MIN) \end{array} $	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30
WD BF NA β f φ _{G1o} φ _s D _{os} D _{O1G2} L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{ing} D _{max} D _{G1max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07	35 Doi	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00
WD BF NA β f ϕ_{G1o} ϕ_s Dos D $_{G1G2}$ L $_{G1}$ L $_{G2}$ CRA $_{obj}$ (MAX) CRA $_{obj}$ (MIN) CRA $_{img}$ D $_{max}$ D $_{G1max}$ vd $_{max}$ vd $_{min}$ N $_{G2}$ f $_{G1}$ f $_{G2}$ f $_{G1o}$ f $_{G2i}$ f $_{L1}$ f $_{L2}$ f $_{L3}$	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88 -13.66 16.27	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83	35 Doi Yobj Y L _{TL} L _L 40 WD BF NA β f φ _{G1o} 45 D _{os} D _{G1G2} L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) 50 CRA _{img} D _{max} νd _{max} νd _{min} N _{G1} 55 N _{G2}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{os} D_{os1G2} L_{G1} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN) CRA_{img} D_{max} Vd_{min} N_{G1} N_{G2} f_{G1o} f_{G2i} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 17.88 -10.56 17.88 -13.66 16.27	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19	35	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90
WD BF NA β f ϕ_{G1o} ϕ_s Dos	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88 -10.56 17.88 -13.66 16.27 13.67 13.67 13.67 13.67	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97	35	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93
WD BF NA β f ϕ_{G1o} ϕ_s Dos DG1G2 LG1 LG2 CRAobj (MAX) CRAobj (MIN) CRAims DG1max vd,max vd,min NG1 NG2 fG1 fG2 fG1o fG2i fL1 fL2 fL3 fL4 fL5 fL6	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -13.66 16.27 13.67 13.69 -5.79	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93	35 Doi Yobj Y L _{IL} L _L 40 WD BF NA β f Φ _{G1o} Φ _s D _{os} D _{G1G2} L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) 50 CRA _{img} D _{max} D _{G1max} vd _{max} vd _{max} vd _{min} N _{G1} 55 N _{G2} f _{G1} f _{G2} f _{G1o}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62
WD BF NA β f ϕ_{G1o} ϕ_s D_{os} D_{os} D_{os} D_{o1G2} L_{G2} CRA_{obj} (MAX) CRA_{obj} (MIN) CRA_{img} D_{max} D_{G1max} vd_{max} vd_{min} N_{G1} N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{G1o} f_{G2i} f_{L1} f_{L2} f_{L3} f_{L4} f_{L5} f_{L6} f_{L7}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -13.66 16.27 13.67 13.67 -5.79 21.18	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43	35 Doi Yobj Y L.T. L. L. UND BF NA B f \$\phi_{G1o}\$ \$\phi_{G1o}\$ 45 \$\phi_{S}\$ \$\D_{G1G2}\$ L.G. \$\CRA_{obj}\$ (MAX) CRA_{obj}\$ (MIN) 50 CRA_{img} \$\D_{max}\$ D_{G1max} \$\vd_{min}\$ N.G. \$\phi_{G1}\$ 55 \$\mathbb{N}_{G2}\$ f.G. f.G. f.G. f.G. f.G	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15
WD BF NA β f ϕ_{G1o} ϕ_s Dos D $_{G1G2}$ L $_{G1}$ CRA $_{obj}$ (MAX) CRA $_{obj}$ (MIN) CRA $_{img}$ D $_{max}$ Vd $_{max}$ Vd $_{min}$ N $_{G2}$ f $_{G1}$ f $_{G2}$ f $_{G1o}$ f $_{G2i}$ f $_{L3}$ f $_{L4}$ f $_{L5}$ f $_{L6}$ f $_{L6}$ f $_{L6}$ f $_{L7}$ f $_{L8}$	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 15.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97	35	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62
WD BF NA β f ϕ_{G1o} ϕ_s Dos	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 15.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94	35	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29
WD BF NA β f ϕ_{G1o} ϕ_s Dos Dos Dos Dos Dos Dos LG1 LG1 LG2 CRAobj (MAX) CRAobj (MIN) CRAimg Dmax vd,min NG1 NG2 fG1 fG2 fG1o fG2i fL1 fL2 fL3 fL4 fL5 fL6 fL7 fL8 fL9 fL10	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76 18.24	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67 16.87	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52 -15.34	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 -11.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94 -17.31	35	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59 8.46	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88 23.28	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51 -54.36 28.64	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29 -40.89
WD BF NA β f ϕ_{G1o} ϕ_s Dos	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 15.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94	35 Doi Yobj Y L _{IL} L _L L _L 40 WD BF NA β f Φ _{G1o} Φ _s Dos Dos DG1G2 L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) 50 CRA _{obj} (MIN) 50 CRA _{obj} (MIN) 50 CRA _{obj} (MIN) 60 f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59 8.46 9.45	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88 23.28 24.16	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51 -54.36 28.64 25.30	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29 -40.89 25.88
WD BF NA β f ϕ_{G1o} ϕ_s Dos Dos Dos Dos Dos Dos LG1 LG1 LG2 CRAobj (MAX) CRAobj (MIN) CRAimg Dmax vd,min NG1 NG2 fG1 fG2 fG1o fG2i fL1 fL2 fL3 fL4 fL5 fL6 fL7 fL8 fL9 fL10	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76 18.24 -9.44	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67 16.87 -10.56	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52 -15.34	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94 -17.31 -11.21	35 $\frac{D_{oi}}{Y_{obj}}$ Y L_{TL} L_{L} 40 WD BF NA β f ϕ_{G1o} 45 ϕ_{s} D_{G1G2} L_{G1} L_{G2} $CRA_{obj}(MIN)$ 50 CRA_{img} D_{G1max} vd_{max} vd_{min} N_{G1} 55 N_{G2} f_{G1} f_{G2} f_{G1o} f_{G2i} f_{G1o}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59 8.46 9.45 -5.84	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88 23.28 24.16 21.16	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51 -54.36 28.64 25.30 16.94	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29 -40.89 25.88 25.01
WD BF NA β f ϕ_{G1o} ϕ_s Dos Dos Dos Dos Dos Dos LG1 LG1 LG2 CRAobj (MAX) CRAobj (MIN) CRAimg Dmax vd,min NG1 NG2 fG1 fG2 fG1o fG2i fL1 fL2 fL3 fL4 fL5 fL6 fL7 fL8 fL9 fL10	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76 18.24	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67 16.87	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52 -15.34	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 -11.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94 -17.31	35 Doi Yobj Y L_{TL} L_{L} L_{L} 40 WD BF NA β f Φ _{G1o} Φ _g D _{os} D _{G1G2} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) 50 CRA _{img} D _{max} D _{G1max} Vd _{min} N _{G1} 55 N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59 8.46 9.45 -5.84 -7.46	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88 23.28 24.16 21.16 -8.36	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51 -54.36 28.64 25.30 16.94 -11.17	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29 -40.89 25.88 25.01 15.79
WD BF NA β f φ _{G1o} φ _s D _{os} D _{O1G2} L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{img} D _{max} vd _{max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L10} f _{L11}	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76 18.24 -9.44 Example16	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67 16.87 -10.56 Example 17	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52 -15.34 — Example18	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94 -17.31 -11.21 Example19	35 Doi	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59 8.46 9.45 -5.84 -7.46 11.13	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88 23.28 24.16 21.16 -8.36 -8.13	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51 -54.36 28.64 25.30 16.94 -11.17 -8.34	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29 -40.89 25.88 25.01 15.79 -10.39
WD BF NA β f ϕ_{G1o} ϕ_s Dos Dos Dos Dos Dos Dos LG1 LG1 LG2 CRAobj (MAX) CRAobj (MIN) CRAimg Dmax vd,min NG1 NG2 fG1 fG2 fG1o fG2i fL1 fL2 fL3 fL4 fL5 fL6 fL7 fL8 fL9 fL10	20.00 2.90 0.18 -1.05 7.99 13.29 5.73 36.58 1.64 15.23 15.23 5.01 0.00 24.98 3.01 0.30 81.61 23.77 6.00 5.00 12.56 65.83 18.32 -9.44 18.32 -12.27 15.26 16.48 12.90 -6.44 -31.52 114.04 19.76 18.24 -9.44	21.00 2.89 0.13 -1.05 8.59 11.27 3.56 35.61 1.24 13.67 16.21 5.02 0.00 24.22 3.60 0.30 81.61 23.77 6.00 5.00 11.59 67.00 17.88 -10.56 17.88 -13.66 16.27 13.67 13.69 -5.79 21.18 -12.33 22.67 16.87 -10.56	24.00 3.13 0.14 -1.05 9.49 12.33 4.32 40.71 1.41 15.60 15.86 4.45 0.00 22.84 3.25 0.45 81.61 23.77 6.00 4.00 11.80 -52.46 18.30 -15.34 18.30 -11.91 13.04 14.27 13.50 -5.96 -27.43 49.38 20.52 -15.34	15.97 3.31 0.21 -1.05 8.84 13.69 6.29 32.22 4.13 14.70 21.90 5.03 0.00 23.11 4.13 2.15 81.61 23.77 5.00 6.00 14.91 12.97 56.21 -11.21 56.21 37.07 24.83 10.19 -5.97 -12.93 14.43 15.97 22.94 -17.31 -11.21	35 Doi Yobj Y L_{TL} L_{L} L_{L} 40 WD BF NA β f Φ _{G1o} Φ _g D _{os} D _{G1G2} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) 50 CRA _{img} D _{max} D _{G1max} Vd _{min} N _{G1} 55 N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6}	50.5 3.7 4.92 36.73 34.85 13.80 1.88 0.23 -1.33 5.76 11.62 5.58 27.52 2.33 12.55 19.96 5.03 0.00 24.38 5.67 0.74 81.61 23.77 5.00 7.00 11.79 20.63 12.16 -11.27 12.16 -9.59 8.46 9.45 -5.84 -7.46	90.0 3.7 4.92 60.00 58.09 30.00 1.91 0.23 -1.33 11.95 18.29 8.60 46.38 2.52 14.93 40.64 3.42 0.00 16.41 16.81 0.10 81.61 23.77 6.00 7.00 15.93 -148.45 27.51 -61.84 27.51 -47.88 23.28 24.16 21.16 -8.36	74.0 3.7 4.92 44.01 42.57 30.00 1.44 0.23 -1.33 9.09 18.37 9.67 45.86 0.72 14.92 26.93 3.77 0.00 14.28 5.38 0.71 81.61 23.77 6.00 7.00 14.56 -15.87 34.51 -112.48 34.51 -54.36 28.64 25.30 16.94 -11.17	75.0 3.7 4.92 45.00 42.76 30.00 2.25 0.23 -1.33 8.95 18.43 9.49 46.52 0.82 15.58 26.36 3.66 0.00 16.19 6.22 0.10 81.61 30.30 7.00 7.00 14.90 -17.93 -433.62 -44.15 -433.62 30.29 -40.89 25.88 25.01 15.79

		-continued						-continued		
f_{L10}	16.62	46.31	-11.47	13.12		f_{G2}	-19.08	-18.81	-27.03	-14.14
f_{L11}	-19.11	23.89	9.84	-11.60		f_{G1o}	36.71	36.28	33.71	46.69
f_{L12}	-11.27	-13.98 -61.84	-9.96 -112.48	9.84 -12.08	5	f_{G2i}	-12.14 36.71	-11.41 36.28	-10.64 33.71	1004.70 46.69
$egin{array}{l} \mathbf{f}_{L13} \\ \mathbf{f}_{L14} \end{array}$		-01.64	-112.46	-12.08 -44.15		$egin{aligned} \mathbf{f}_{L1} \ \mathbf{f}_{L2} \end{aligned}$	40.13	44.47	57.34	46.74
*L14						f_{L3}	21.15	19.96	18.06	25.46
	Example24	Example25	Example26	Example27		f_{L4}	24.31	23.47	20.89	13.56
						f_{L5}	-22.06	-21.47	-17.23	-12.34
D_{oi}	70.0	67.0	67.0	67.0	10	f_{L6}	-9.37	-9.35	-9.76	-8.13
\mathbf{Y}_{obj} \mathbf{Y}	2.2 4.92	1.9 4.92	1.9 4.92	1.9 4.92	10	$egin{array}{l} f_{L7} \ f_{L8} \end{array}$	13.36 34.78	13.37 34.82	13.67 33.26	11.38 38.36
$\stackrel{1}{\mathbb{L}_{TL}}$	54.21	55.51	51.22	51.22		f_{L9}	-104.76	-93.84	16.88	270.72
L_L	51.58	52.41	49.41	49.09		f_{L10}	15.68	14.70	-15.01	13.62
WD	15.80	11.50	15.80	15.80		f_{L11}	-14.06	-13.63	-10.64	-6.90
BF	2.63	3.10	1.81	2.13		f_{L12}	-12.14	-11.41	_	1004.70
NA β	0.38 -2.20	0.43 -2.55	0.40 -2.55	0.40 -2.55	15		Example32	Example33	Example34	Example35
f	5.02	4.06	4.53	4.30			Example 32	Lxample33	Example34	Lxample33
ϕ_{G1o}	16.68	14.25	16.84	16.89		D_{oi}	70.0	74.0	62.7	63.0
Φ_s	11.49	11.77	12.92	12.50		Y_{obj}	2.5	3.7	3.7	3.7
D_{os}	32.14	27.52	31.44	30.95		Y	4.92	4.92	4.92	4.92
D_{G1G2}	0.96 15.55	1.10 15.33	0.36 15.63	0.52 15.10	20	$egin{array}{c} L_{T\!L} \ L_{L} \end{array}$	44.98 42.01	44.01 38.79	46.52 45.18	46.88 45.36
L_{G1} L_{G2}	35.06	35.97	33.42	33.47		$\stackrel{L_L}{ ext{WD}}$	25.04	30.00	16.17	16.07
$CRA_{obj}(MAX)$	3.01	3.02	3.01	3.02		BF	2.96	5.22	1.34	1.52
$CRA_{obi}(MIN)$	0.00	0.00	0.00	0.00		NA	0.23	0.23	0.23	0.23
CRA_{img}	19.17	20.97	14.87	16.57		β	-2.00	-1.33	-1.33	-1.33
D_{max}	8.48 0.10	12.20 0.71	11.08 0.70	11.58 0.43	25	f	10.51 14.46	10.24 19.03	6.71 13.17	6.94 13.35
D_{G1max} vd_{max}	81.61	81.61	81.61	81.61		$oldsymbol{\phi}_{G1o} \ oldsymbol{\phi}_s$	8.46	9.19	5.88	5.84
vd _{min}	23.77	23.77	23.77	23.77		$\overset{\mathbf{r}_{s}}{\mathbf{D}}_{os}$	36.91	47.62	33.61	33.98
N_{G1}	6.00	6.00	6.00	5.00		D_{G1G2}	0.16	0.54	1.53	2.17
N_{G2}	7.00	7.00	7.00	7.00		L_{G1}	11.38	16.67	16.47	16.61
f_{G1}	14.02	12.99	12.42	12.17	30	L _{G2}	30.47	21.58	27.18	26.59
f _{G2} f _{G10}	919.29 19.51	85.22 15.80	-9.39 25.17	-9.08 28.64	30	$CRA_{obj}(MAX)$ $CRA_{obj}(MIN)$	3.30 0.00	3.22 0.00	3.54 0.00	3.17 0.00
f_{G2i}	-20.20	-13.47	-21.78	-18.62		CRA _{img}	12.08	16.48	25.00	25.00
f_{L1}	19.51	15.80	25.17	28.64		D _{max}	9.72	5.87	5.23	5.15
f_{L2}	-30.65	-25.58	-77.15	43.10		$DG1_{max}$	0.30	0.10	0.96	0.92
f_{L3}	25.01	23.90	32.04	19.95		vd_{max}	81.61	81.61	81.61	81.61
f_{L4}	22.31 19.81	23.14 18.73	20.04 26.48	22.33 -18.00	35	vd _{min}	23.77 5.00	23.77 6.00	23.77 6.00	23.77 6.00
f_{L5} f_{L6}	-10.74	-11.95	-20.40	-9.19		$N_{G1} \ N_{G2}$	6.00	6.00	7.00	6.00
f_{L7}	-10.27	-11.22	-9.37	15.85		f_{G1}	12.00	15.66	11.76	11.71
f_{L8}	13.10	14.37	15.36	21.65		f_{G2}	-16.50	-40.91	416.18	-1160.10
f_{L9}	22.47	24.09	22.49	-14.46		f_{G1o}	43.72	41.25	13.37	13.51
f_{L10}	-26.66 12.62	-50.83 12.52	-12.32 9.13	9.47 -9.78	40	f_{G2i}	100.51 43.72	-10.63 41.25	-22.33 13.37	-16.72 13.51
$egin{array}{l} \mathbf{f}_{L11} \ \mathbf{f}_{L12} \end{array}$	-10.03	-10.05	-9.73	-18.62		$egin{aligned} \mathbf{f}_{L1} \ \mathbf{f}_{L2} \end{aligned}$	32.19	-52.01	-11.61	-11.84
f_{L13}	-20.20	-13.47	-21.78	_		f_{L3}	28.02	20.63	16.56	16.66
						f_{L4}	14.03	27.75	16.39	16.73
	Example28	Example29	Example30	Example31		f_{L5}	-11.74	18.33	11.85	12.07
D	67.0	67.0	67.0	60.0	45	f_{L6}	-7.83 14.26	-9.85 -10.09	-6.77 -8.39	-7.04 -8.08
\mathbf{Y}_{obj}	67.0 3.1	67.0 3.2	3.2	60.0 2.5		$egin{aligned} \mathbf{f_{L7}} \\ \mathbf{f_{L8}} \end{aligned}$	41.26	20.06	14.89	14.88
Y	4.92	4.92	4.92	4.92		f_{L9}	14.80	12.65	25.19	17.50
\mathcal{L}_{TL}	50.99	50.97	50.83	39.12		f_{L10}	-9.79	-9.90	46.83	19.53
L_L	49.18	49.16	49.02	36.64		f_{L11}	100.51	8.86	19.06	-15.02
WD BF	16.02 1.81	16.04 1.81	16.18 1.81	20.90 2.48	50	f_{L12} f_{L13}	_	-10.63	-11.47	-16.72
NA	0.40	0.31	0.31	0.20	50	¹ L13			-22.33	
β	-1.60	-1.56	-1.55	-2.00			Example36	Example37	Example38	Example39
f	5.39	5.41	5.52	6.48			•			
ϕ_{G1o}	18.74	14.61	14.78	10.53		D_{oi}	64.1	65.0	74.6	65.2
Φ_s	13.40	10.17	10.06	6.66		Y_{obj}	3.7	3.7	3.7	3.8
D_{os}	30.52 0.73	31.48 1.01	30.31 0.78	30.56 0.35	55	$\mathrm{Y}_{L_{T\!L}}$	4.92 47.90	4.92 48.69	4.92 53.56	4.92 48.01
D_{G1G2} L_{G1}	14.68	15.41	14.04	9.16		L_L	44.23	47.50	49.95	45.78
L_{G2}	33.77	32.74	34.20	27.13		$\overline{\mathrm{WD}}$	16.16	16.30	21.00	17.18
$CRA_{obj}(MAX)$	5.01	4.86	5.01	4.25		BF	3.68	1.19	3.62	2.23
CRA _{obi} (MIN)	0.00	0.00	0.00	0.00		NA	0.23	0.23	0.23	0.23
CRA_{img}	24.98	24.99	24.99	13.24	60		-1.33	-1.33	-1.33	-1.30
D_{max}	6.33	6.37	8.18	5.26		f	8.73	8.25	9.31	11.64
D_{G1max}	0.44	0.54	0.64	0.10		φ _{G10}	13.51	13.57	15.22	14.22
vd _{max}	81.61 23.77	81.61 23.77	81.61 23.77	81.61 23.77		Φ_s D_{os}	5.94 34.66	5.87 34.69	6.90 40.82	6.93 37.85
vd_{min}	43.11	43.11	43.11	43.11		1100	J4.00	シサ・リン	40.02	21.03
No				5.00		Dorm				0.87
N_{G1} N_{G2}	5.00	5.00	5.00	5.00 7.00	65	D_{GLG2}	2.23	2.15	2.29	0.87 20.17
$egin{array}{l} \mathbf{N}_{G1} \ \mathbf{N}_{G2} \ \mathbf{f}_{G1} \end{array}$					65	D_{G1G2} L_{G1} L_{G2}				

		2/1						212		
		-continued						-continued		
CRA _{obj} (MAX)	3.04	3.04	3.19	3.59		L_L	47.27	47.29	47.30	47.32
CRA_{obj} (MIN) CRA_{img}	0.00 20.87	0.00 18.64	0.00 15.64	0.00 10.46		WD BF	15.85 1.88	15.83 1.88	15.82 1.88	15.80 1.88
D_{max}	5.08	5.21	4.86	3.62	5	NA	0.23	0.23	0.20	0.23
DG1 _{max}	0.92	0.79	0.30	1.32		β	-1.33	-1.33	-1.33	-1.33
vd _{max}	81.61	81.61	81.61	81.61		f	7.87	7.55	7.55	8.00
vd _{min}	23.77	23.77	23.77	32.36		ϕ_{G1o}	12.90	12.18	11.08	13.30
N_{G1}	6.00	6.00	6.00	6.00		Φ_s	5.98	6.43	5.65	6.02
N_{G2}	5.00	7.00	6.00	5.00		D_{os}	33.07	31.52	30.90	34.46
f_{G1}	11.61	11.76	12.68	11.29	10	- 0102	1.91	2.11	1.98	4.00
f_{G2}	238.11	152.21	-40.68	-27.34		L_{G1}	16.14	14.43	13.84	16.69
f_{G1o} f_{G2i}	13.83 -8.72	13.48 1846.69	15.35 -9.62	30.09 -13.42		$\begin{array}{c} \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj}\left(\mathbf{MAX}\right) \end{array}$	29.23 3.85	30.75 4.92	31.48 5.03	26.63 3.03
f_{L1}^{G2i}	13.83	13.48	15.35	30.09		$CRA_{obj}(MIN)$	0.00	0.00	0.00	0.00
\mathbf{f}_{L2}	-11.77	-11.53	-13.63	-26.10		CRA _{img}	25.01	25.01	25.01	24.94
f_{L3}^{L2}	17.05	15.57	17.12	16.79	15	D_{max}^{img}	9.60	14.60	15.60	4.94
f_{L4}	16.34	17.36	17.69	23.91		D_{G1max}	0.72	0.57	0.95	0.51
f_{L5}	12.87	11.81	16.75	21.98		vd_{max}	81.61	81.61	81.61	81.61
f_{L6}	-7.52	-6.86	-8.50	-25.35		vd_{min}	23.77	23.77	23.77	23.77
f_{L7}	-7.59	-8.30	-7.69	24.96		N_{G1}	6.00	6.00	6.00	6.00
f_{L8}	15.13	14.58	18.30	-6.92		N_{G2}	6.00	6.00	6.00	6.00
$egin{aligned} \mathbf{f_{L9}} \\ \mathbf{f_{L10}} \end{aligned}$	16.05 21.08	19.96 85.87	36.70 26.35	183.01 13.30	20	f_{G1} f_{G2}	11.80 91.51	13.57 24.06	14.24 18.81	11.71 -451.46
f_{L11}	-8.72	19.60	19.77	-13.42		f_{G1o}	13.54	14.77	14.79	14.48
\mathbf{f}_{L12}		-8.10	-9.62			f_{G2i}	-18.99	-12.64	-12.42	-15.93
f_{L13}^{L12}	_	1846.69	_	_		f_{L1}	13.54	14.77	14.79	14.48
						f_{L2}	-13.28	-17.01	-17.43	-12.43
	Example40	Example41	Example42	Example43	25	f_{L3}	16.99	23.54	22.87	16.62
					. 23	f_{L4}	18.92	19.07	19.69	18.07
D_{oi}	64.2	54.5	54.1	65.0		f_{L5}	12.23	14.42	14.57	15.43
Y _{obj} Y	3.8 4.92	3.6 4.75	3.6 4.75	3.7 4.92		f_{L6}	-6.91 -8.30	−7.15 −11.29	-6.88 -12.11	-8.97 -7.82
$\stackrel{_{_{\scriptstyle I}}}{\mathbb{L}_{TL}}$	4.92 47.64	43.00	43.00	49.10		$egin{array}{l} f_{L7} \ f_{L8} \end{array}$	25.05	-11.29 44.46	44.73	14.98
\mathcal{L}_{L}	45.52	41.24	41.24	47.62		f_{L9}	13.37	12.12	12.07	15.98
$\overline{\mathrm{WD}}$	16.60	11.49	11.12	15.90	30	f_{L10}	21.39	21.40	21.25	25.19
BF	2.12	1.76	1.76	1.48		f_{L11}^{L10}	-17.93	-31.10	-31.18	-19.41
NA	0.23	0.23	0.23	0.23		f_{L12}	-18.99	-12.64	-12.42	-15.93
β	-1.30	-1.32	-1.32	-1.33						
f	11.19	5.34	5.31	7.78			Example48	Example49	Example50	Example51
ϕ_{G1o}	14.42	11.43	10.95	7.78 13.19	25					
Φ_{G1o} Φ_s	14.42 6.70	11.43 7.60	10.95 7.60	7.78 13.19 5.86	35		65.0	65.0	88.4	86.6
$egin{array}{l} oldsymbol{\phi}_{G1o} \ oldsymbol{\phi}_s \ D_{os} \end{array}$	14.42 6.70 38.48	11.43 7.60 30.69	10.95 7.60 30.14	7.78 13.19 5.86 33.82	35	Y_{obj}	65.0 3.7	65.0 3.7	88.4 3.5	86.6 3.7
$egin{array}{l} oldsymbol{\varphi}_{G1o} \ oldsymbol{\varphi}_s \ D_{os} \ D_{G1G2} \end{array}$	14.42 6.70	11.43 7.60	10.95 7.60	7.78 13.19 5.86	35	\mathbf{Y}_{obj} \mathbf{Y}	65.0	65.0	88.4	86.6
$egin{array}{l} oldsymbol{\psi}_{G1o} \ oldsymbol{\psi}_s \ D_{os} \ D_{G1G2} \ L_{G1} \ L_{G2} \end{array}$	14.42 6.70 38.48 1.85	11.43 7.60 30.69 2.15	10.95 7.60 30.14 1.09 18.23 21.93	7.78 13.19 5.86 33.82 2.17	35	Y_{obj}	65.0 3.7 4.92	65.0 3.7 4.92	88.4 3.5 4.92	86.6 3.7 4.92
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01	11.43 7.60 30.69 2.15 17.35 21.74 3.44	10.95 7.60 30.14 1.09 18.23 21.93 3.94	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44	35	$egin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00	65.0 3.7 4.92 48.98 47.09 16.02	88.4 3.5 4.92 56.76 46.38 31.64	86.6 3.7 4.92 55.68 44.80 30.90
ϕ_{G1o} ϕ_s D_{os} D_{G1G2} L_{G1} L_{G2} $CRA_{obj}(MAX)$ $CRA_{obj}(MIN)$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00	35	$egin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88	65.0 3.7 4.92 48.98 47.09 16.02 1.89	88.4 3.5 4.92 56.76 46.38 31.64 10.38	86.6 3.7 4.92 55.68 44.80 30.90 10.88
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01		$egin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19		$egin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{eta} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{GImax} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79		$egin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61		$egin{array}{ll} egin{array}{ll} egi$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77	40	$egin{array}{ll} egin{array}{ll} egi$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61		$egin{array}{ll} egin{array}{ll} egin{array}{ll} egin{array}{ll} egin{array}{ll} egin{array}{ll} L_{IL} & egin{array}{ll} egin{array} egin{array}{ll} egin{array}{ll} egin{array}{ll} egin{array} egin{array}{ll} egin{array}{ll} egin{array}{ll} egin{array} egin{array}{ll} egin{array}{ll} egin{array}{ll} egin{a$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28	40	$egin{array}{l} egin{array}{l} egin{array}{l} egin{array}{l} egin{array}{l} egin{array}{l} L_{IL} \ egin{array}{l} eg$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12	40	$egin{array}{ll} egin{array}{ll} egi$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55	40	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{I\!I\!I} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \boldsymbol{\beta} \\ \mathbf{f} \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj}(\mathbf{MAX}) \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68	40	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\Phi}_{G1o} \\ \mathbf{\Phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1j} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55	40	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{inter} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00	40	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} (\mathbf{ming}) \\ \mathbf{D}_{max} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55	40	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} \\ (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{D}_{GImax} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ Vd_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05	40	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\Phi}_{G1o} \\ \mathbf{\Phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{D}_{Gilmax} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L5} \\ f_{L6} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41	40	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{W} \\ \mathbf{D} \\ \mathbf{B} \\ \mathbf{F} \\ \mathbf{N} \\ \mathbf{A} \\ \mathbf{\beta} \\ \mathbf{f} \\ \\ \boldsymbol{\phi}_{S} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ 0_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00
$\begin{array}{l} \varphi_{G1o} \\ \varphi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57	40 45 50	$\begin{array}{c} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \boldsymbol{\beta} \\ \boldsymbol{\beta} \\ \mathbf{f} \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \boldsymbol{D}_{os} \\ \mathbf{D}_{os} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} \\ (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ \boldsymbol{M}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 6.00	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L6} \\ f_{L6} \\ f_{L6} \\ f_{L7} \\ f_{L8} \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \boldsymbol{\beta} \\ \mathbf{f} \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \boldsymbol{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 6.00 15.01	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{IL} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\Phi}_{G1o} \\ \mathbf{\Phi}_{s} \\ \mathbf{D}_{Gs} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{D}_{O1max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L9} \\ f_{L10} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \\ \boldsymbol{\Phi_{G1o}} \\ \boldsymbol{\Phi_{S}} \\ \mathbf{D}_{Os} \\ \mathbf{D}_{Os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{D}_{G1max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1o} \\ \\ \mathbf{f}_{G1o} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 15.391 19.51	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G2} \\ f_{G1} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G1} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G1} \\ f_{G1} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G1} \\ f_{G1} \\ f_{G1} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G3} \\ f_{G3} \\ f_{G4} \\ f_{G2} \\ f_{G3} \\ f_{G3} \\ f_{G4} \\ f_{G3} \\ f_{G4} \\ f_{G$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\phi}_{G1o} \\ \mathbf{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{Vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2i} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 1	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13	40 45 50	$\begin{array}{l} Y_{obj} \\ Y \\ Y \\ L_{IZ} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MIN) \\$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 15.391 19.51 -18.39 19.51	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 -46.90 28.65 -11.38 28.65
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L22} \\ f_{L11} \\ f_{L23} \\ f_{L11} \\ f_{L23} \\ f_{L11} \\ f_{L24} \\ f_{L15} \\ f_{L25} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89 -17.68	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\phi}_{G1o} \\ \mathbf{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ \mathbf{f}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2i} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84 -13.04	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -18.39 19.51 -12.13	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -18.66
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{IL} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\Phi}_{G1o} \\ \mathbf{\Phi}_{s} \\ \mathbf{D}_{Gs} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CR}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} \\ \mathbf{f}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2i} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \\ \mathbf{f}_{L3} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84 -13.04 18.46	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -12.13 18.52	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -18.66 20.10
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L22} \\ f_{L11} \\ f_{L23} \\ f_{L11} \\ f_{L23} \\ f_{L11} \\ f_{L24} \\ f_{L15} \\ f_{L25} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09 —	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70 -8.02	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89 -17.68	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \\ \mathbf{\phi}_{o1o} \\ \mathbf{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{o1o2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2i} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L4} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84 -18.74 -18.74 -18.74 -18.74 -18.74 -18.74 -18.74 -18.74 -18.74 -18.75 -18.74 -18.74 -18.74 -18.74 -18.74 -18.75	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -18.39 19.51 -12.13 18.52 16.97	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01 22.79	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -18.66 20.10 22.92
$\begin{array}{l} \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L22} \\ f_{L11} \\ f_{L23} \\ f_{L11} \\ f_{L23} \\ f_{L11} \\ f_{L24} \\ f_{L15} \\ f_{L25} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ \end{array}$	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89 -17.68	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{U}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\phi}_{G1o} \\ \mathbf{\phi}_{s} \\ \mathbf{D}_{G6} \\ \mathbf{CRA}_{obj} \\ \mathbf{(MIN)} \\ \mathbf{CRA}_{obj} \\ \mathbf{(MIN)} \\ \mathbf{CRA}_{obj} \\ \mathbf{(MIN)} \\ \mathbf{CRA}_{obj} \\ \mathbf{(MIN)} \\ \mathbf{CRA}_{obj} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2i} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L4} \\ \mathbf{f}_{L5} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84 -18.74 -18.75	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -18.39 19.51 -12.13 18.52 16.97 63.84	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01 22.79 22.94	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -11.38 28.65 -18.66 20.10 22.92 22.12
$ \begin{aligned} & \varphi_{G1o} \\ & \varphi_s \\ & D_{os} \\ & D_{G1G2} \\ & L_{G1} \\ & L_{G2} \\ & CRA_{obj}(MAX) \\ & CRA_{obj}(MIN) \\ & CRA_{img} \\ & D_{max} \\ & D_{G1max} \\ & vd_{max} \\ & vd_{min} \\ & N_{G2} \\ & f_{G1} \\ & f_{G2} \\ & f_{G1} \\ & f_{G2} \\ & f_{L1} \\ & f_{L2} \\ & f_{L3} \\ & f_{L4} \\ & f_{L5} \\ & f_{L6} \\ & f_{L7} \\ & f_{L8} \\ & f_{L9} \\ & f_{L10} \\ & f_{L111} \\ & f_{L12} \\ & f_{L13} \\ & f_{L14} \\ \end{aligned} $	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02 Example45	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70 -8.02 Example46	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 16.82 17.00 16.82 23.13 -16.89 -17.68 Example47	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{Y} \\ \mathbf{L}_{TL} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{f} \\ \mathbf{\phi}_{G1o} \\ \mathbf{\phi}_{s} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L4} \\ \mathbf{f}_{L5} \\ \mathbf{f}_{L5} \\ \mathbf{f}_{L6} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84 -18.75 -1	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -18.39 19.51 -12.13 18.52 16.97 63.84 -23.74	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01 22.79 22.94 -12.18	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -18.66 20.10 22.92 22.12 -11.48
φ _{G1ο} φ _s D _{os} D _{os} D _{G1G2} L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{img} D _{max} D _{G1max} vd _{max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L11} f _{L11} f _{L12} f _{L10} f _{L11} f _{L11} f _{L12} f _{L10} f _{L11} f _{L11} f _{L11} f _{L11} f _{L12} f _{L11} f _{L12} f _{L11} f _{L12} f _{L13} f _{L11} f _{L11} f _{L11} f _{L12} f _{L11} f _{L11} f _{L12} f _{L11} f _{L12} f _{L11} f _{L12} f _{L13} f _{L11}	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09 —	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70 -8.02	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89 -17.68	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{U} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \mathbf{p}_{os} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} (\mathbf$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -18.73 17.84 -18.74 -18.75	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -18.39 19.51 -12.13 18.52 16.97 63.84	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01 22.79 22.94 -12.18 -10.31	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -11.38 28.65 -18.66 20.10 22.92 22.12
$ \begin{aligned} & \varphi_{G1o} \\ & \varphi_s \\ & D_{os} \\ & D_{G1G2} \\ & L_{G1} \\ & L_{G2} \\ & CRA_{obj}(MAX) \\ & CRA_{obj}(MIN) \\ & CRA_{img} \\ & D_{max} \\ & D_{G1max} \\ & vd_{max} \\ & vd_{min} \\ & N_{G2} \\ & f_{G1} \\ & f_{G2} \\ & f_{G1} \\ & f_{G2} \\ & f_{L1} \\ & f_{L2} \\ & f_{L3} \\ & f_{L4} \\ & f_{L5} \\ & f_{L6} \\ & f_{L7} \\ & f_{L8} \\ & f_{L9} \\ & f_{L10} \\ & f_{L111} \\ & f_{L12} \\ & f_{L13} \\ & f_{L14} \\ \end{aligned} $	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09 — — Example44 65.0	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02 Example45	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70 -8.02 Example46	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89 -17.68 Example47	40 45 50	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{U} \\ \mathbf{D} \\ \mathbf{D} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \mathbf{\phi}_{G1o} \\ \mathbf{\phi}_{s} \\ \mathbf{D}_{Os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{D}_{O1max} \\ \mathbf{vd}_{max} \\ \mathbf{vd}_{min} \\ \mathbf{N}_{G1} \\ \mathbf{N}_{G2} \\ \mathbf{f}_{G1} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{G1o} \\ \mathbf{f}_{G2} \\ \mathbf{f}_{L1} \\ \mathbf{f}_{L2} \\ \mathbf{f}_{L3} \\ \mathbf{f}_{L4} \\ \mathbf{f}_{L5} \\ \mathbf{f}_{L6} \\ \mathbf{f}_{L6} \\ \mathbf{f}_{L7} \\ \mathbf{f}_{L8} \\ \end{array}$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 0.36 81.61 23.77 6.00 6.00 13.24 -4737.68 17.84 -13.04 18.46 17.54 30.17 -15.22 -10.47	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -12.13 18.52 16.97 63.84 -23.74 -13.12	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01 22.79 22.94 -12.18	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 4.33 2.58 81.61 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -11.38 28.65 -11.48 -1.4
φ _{G1ο} φ _s D _{os} D _{os} D _{os} D _{G162} L _{G1} L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{img} D _{max} D _{G1max} vd _{max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L11} f _{L12} f _{L11} f _{L12} f _{L13} f _{L11} f _{L12} f _{L11} f _{L11} f _{L12} f _{L11} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L111} f _{L111} f _{L12} f _{L113} f _{L114}	14.42 6.70 38.48 1.85 20.97 22.70 3.01 0.00 10.83 3.03 1.32 81.61 34.71 6.00 5.00 12.35 -163.05 17.51 -14.09 17.51 -15.40 18.06 30.22 14.86 -12.27 13.83 -7.40 -763.86 13.22 -14.09 — — — — — — — — Example44 65.0 3.7	11.43 7.60 30.69 2.15 17.35 21.74 3.44 0.00 31.50 5.48 5.37 81.61 23.78 6.00 7.00 16.76 16.34 -95.25 -8.02 -95.25 15.53 -10.25 9.23 10.02 -8.45 -19.97 15.92 31.04 10.32 -12.97 1200.49 -8.02 -8.02 -8.02 -8.02 -8.03 -10.35 -10.35 -10.35 -10.35 -10.35 -10.37 -10.37 -10.38 -10.39 -10.30 -10.30 -10.30 -10.30 -10.31 -10.31 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.32 -10.31 -10.3	10.95 7.60 30.14 1.09 18.23 21.93 3.94 0.00 31.28 5.63 5.63 5.63 81.61 23.78 6.00 8.00 15.57 50.69 15.42 -8.02 15.42 -95.25 -10.36 9.23 10.82 -10.39 -13.77 18.92 46.98 60.83 9.60 -13.50 247.70 -8.02 Example46 65.0 3.7	7.78 13.19 5.86 33.82 2.17 16.89 28.56 3.44 0.00 25.01 5.19 0.79 81.61 23.77 6.00 6.00 11.28 -144.12 13.55 -17.68 13.55 -12.00 16.82 17.00 12.05 -7.41 -7.57 14.99 16.82 23.13 -16.89 -17.68 Example47	40 45 50 55	$\begin{array}{l} \mathbf{Y}_{obj} \\ \mathbf{Y} \\ \mathbf{L}_{IL} \\ \mathbf{U} \\ \mathbf{L}_{L} \\ \mathbf{WD} \\ \mathbf{BF} \\ \mathbf{NA} \\ \mathbf{\beta} \\ \mathbf{f} \\ \\ \boldsymbol{\phi}_{G1o} \\ \boldsymbol{\phi}_{s} \\ \mathbf{p}_{os} \\ \mathbf{D}_{os} \\ \mathbf{D}_{G1G2} \\ \mathbf{L}_{G1} \\ \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj} (\mathbf{MAX}) \\ \mathbf{CRA}_{obj} (\mathbf{MIN}) \\ \mathbf{CRA}_{obj} (\mathbf$	65.0 3.7 4.92 49.00 47.12 16.00 1.88 0.20 -1.33 7.74 12.20 5.88 35.51 8.50 15.31 23.30 3.02 0.00 24.98 8.50 6.00 6.00 13.24 -4737.68 17.84 -13.04 18.46 17.54 30.17 -15.22 -10.47 20.62	65.0 3.7 4.92 48.98 47.09 16.02 1.89 0.20 -1.33 7.45 12.20 6.58 36.89 11.00 15.45 20.64 3.01 0.00 24.96 11.00 0.67 81.61 23.77 6.00 6.00 15.01 153.91 19.51 -12.13 18.52 16.97 63.84 -23.74 -13.12 25.33	88.4 3.5 4.92 56.76 46.38 31.64 10.38 0.17 -1.40 14.81 14.75 7.84 53.84 1.06 21.29 24.03 3.01 0.00 10.94 7.57 2.79 81.61 23.77 6.00 6.00 16.44 -32.88 26.68 -11.47 26.68 -18.02 20.01 22.79 22.94 -12.18 -10.31 37.48	86.6 3.7 4.92 55.68 44.80 30.90 10.88 0.20 -1.33 14.41 17.05 9.19 54.48 1.10 22.38 21.32 3.01 0.00 11.81 23.77 6.00 6.00 17.09 -46.90 28.65 -11.38 28.65 -18.66 20.10 22.92 22.12 -11.48 -10.82 33.16

		-continued						-continued		
f_{L11}	-16.22	-15.24	11.28	10.23		f_{L2}	62.82	20.87	-33.07	-30.71
f_{L12}	-18.73	-18.39	-11.47	-11.38		f_{L3}	15.66	13.01	20.09	19.65
	E1-52	E1-52	E1-54	D1-66	5	f_{L4}	-16.51	-13.25 -9.05	32.66	29.48
	Example52	Example53	Example54	Example55		f_{L5} f_{L6}	-7.43 18.11	-9.03 17.01	20.45 -10.48	19.15 -11.24
D_{oi}	90.0	87.0	90.0	78.8		f_{L7}	25.89	27.28	-10.19	-8.32
Y.L	3.5	3.5	3.5	4.5		f_{L8}	-396.91	15.71	17.32	12.55
${\displaystyle \mathop{\mathrm{Y}}_{obj}} {\displaystyle \mathop{\mathrm{Y}}}$	4.92	4.92	4.92	4.92		f_{L9}	14.48	-9.54	19.42	-44.70
L_{TL}	58.18	55.96	58.18	44.95		$f_{r_{10}}$	-14.11	-92.10	-19.26	13.63
L_L	45.80	42.08	45.80	42.11	10	f_{L11}	-26.89		-10.89	-9.44
WD	31.82	31.04	31.82	33.80						
BF	12.38	13.88	12.38	2.85			Example60	Example61	Example62	Example63
NA β	0.17 -1.40	0.17 -1.40	0.17 -1.40	0.23 -1.10		D_{oi}	85.0	88.4	88.6	60.2
f f	15.30	15.97	15.30	12.36		Y_{obj}	3.7	2.2	2.2	1.3
ϕ_{G1o}	14.80	14.13	14.80	22.36	15		4.92	7.93	7.93	4.75
φ,	8.07	8.06	8.07	9.00	13	L_{TL}	55.20	86.88	86.93	59.29
D_{as}	54.96	51.40	54.96	53.58		L_L	51.67	74.30	74.81	53.77
D_{G1G2}	1.00	0.95	1.00	1.13		WD	29.80	1.54	1.64	0.88
L_{G1}	22.24	19.48	22.24	18.25		BF	3.54	12.58	12.12	5.52
L _{G2}	22.57	21.65	22.57	22.73		NA	0.23	0.60	0.60	0.60
CRA _{obj} (MAX)	3.01 0.00	3.42 0.00	3.01 0.00	3.01 0.00	20	β f	-1.33 10.62	-3.57 8.96	-3.56 8.92	-3.56
$CRA_{obj}(MIN)$ CRA_{img}	10.57	9.64	10.57	16.01		1 Φ _{G10}	18.57	5.78	5.87	4.98 3.52
D_{max}	6.35	6.45	6.35	2.81		ϕ_s	10.87	11.87	11.92	7.54
D_{Glmm}	2.65	2.30	2.65	0.30		\mathbf{D}_{os}	48.94	27.31	27.45	17.61
vd _{max}	81.61	81.61	81.61	81.61		D_{G1G2}^{∞}	1.25	2.47	2.34	1.38
vd_{min}	23.77	23.77	23.77	23.77	25	L_{G1}	17.64	24.13	24.30	15.92
N_{G1}	6.00	6.00	6.00	5.00	25	L_{G2}	32.78	47.70	48.17	36.46
N_{G2}	6.00	6.00	6.00	7.00		CRA _{obj} (MAX)	3.28	4.92	4.96	4.69
f_{G1}	16.59	15.95	16.59	14.96		CRA _{obj} (MIN)	0.00	0.00	0.00	0.00
f _{G2} f _{G10}	-32.02 26.47	-37.38 25.52	-32.02 26.47	-35.27 154.11		CRA _{img}	16.87 8.57	11.98 9.46	12.41 9.47	14.58 13.98
f_{G2i}^{G1o}	-11.85	-13.78	-11.85	-13.99		D_{max} D_{G1max}	0.30	0.08	0.07	0.05
f_{L1}	26.47	25.52	26.47	154.11	30	vd _{max}	81.61	81.61	81.61	81.61
\mathbf{f}_{L2}	-17.67	-17.71	-17.67	30.29		vd_{min}	23.77	23.88	23.88	23.88
f_{L3}	20.13	21.91	20.13	41.05		N_{G1}	8.00	6.00	6.00	5.00
f_{L4}	22.35	20.68	22.35	13.24		N_{G2}	6.00	7.00	7.00	6.00
f_{L5}	22.74	21.08	22.74	-9.43		f_{G1}	18.97	10.24	10.30	6.64
f_{L6}	-12.18 -10.12	-11.88 -9.91	-12.18 -10.12	-10.58 27.16	2.5	f_{G2}	364.23 32.31	18.57 -22.52	18.54 -22.27	11.47 -25.76
$egin{array}{c} f_{L7} \ f_{L8} \end{array}$	38.42	-9.91 37.46	38.42	10.93	33	$egin{aligned} &\mathbf{f}_{G1},\ &\mathbf{f}_{G2i} \end{aligned}$	-11.62	-22.32 -34.87	-22.27 -34.37	-17.38
f_{L9}	10.60	10.57	10.60	-10.48		f_{L1}	32.31	-22.52	-22.27	-25.76
f_{L10}	-11.69	-12.74	-11.69	9.62		f_{L2}	-41.97	14.55	14.55	11.65
f_{L11}	11.21	12.21	11.21	459.63		f_{L3}	19.06	-58.25	-58.50	10.78
f_{L12}	-11.85	-13.78	-11.85	-13.99		f_{L4}	20.24	14.89	14.91	10.05
					40	f_{L5}	-12.81	12.86	12.99	-5.69
	Example56	Example57	Example58	Example59		f_{L6}	-13.01	-8.25	-8.28	-7.62
D_{oi}	69.8	70.0	84.0	85.0	•	f_{L7}	16.75 21.90	-14.37 17.69	-14.41 17.68	10.65 12.13
Y_{obj}	3.1	3.1	3.7	3.7		f_{L8} f_{L9}	-24.06	17.56	17.53	17.05
Y	4.92	4.92	4.92	4.92		f_{L10}	15.59	-153.28	-146.40	-55.91
L_{TL}	45.08	46.29	54.27	55.20		free	-11.62	26.23	26.02	-17.38
L_L	43.19	42.91	50.28	51.33	45	f_{L12}	_	-70.61	-71.96	_
WD	24.76	23.71	29.74	29.80		f_{L13}	_	-34.87	-34.37	_
BF	1.89	3.38	3.99	3.87			Example64	E1-65	E1-66	E1-67
NA 8	0.20 -1.56	0.20 -1.60	0.23 -1.33	0.23 -1.33			Ехапіріе04	Example65	Example66	Example67
β f	7.72	8.33	9.33	10.42		D_{oi}	68.2	64.9	63.7	121.9
• Ф _{G10}	13.97	12.57	19.32	18.99	50	Y_{obj}	1.5	1.5	1.5	3.0
ϕ_s	7.44	8.16	9.84	9.81		Y	5.50	5.50	5.23	10.82
D_{os}	40.08	35.89	49.92	49.35		L_{TL}	67.34	63.81	62.20	119.67
D_{G1G2}	1.56	0.43	2.56	1.59		L_L	61.51	55.39	54.53	102.94
L_{G1}	14.06	11.71	18.40	18.52		WD	0.88	1.13	1.49	2.27
L _{G2}	27.56	30.78	29.32	31.22		BF	5.83	8.43	7.67	16.73
CRA _{obj} (MAX)	3.14	4.34 0.00	2.81 0.00	3.15 0.00	55	NA o	0.60	0.60	0.60	0.60
CRA_{obj} (MIN) CRA_{img}	0.00 20.33	18.96	18.64	17.68		β f	-3.56 5.34	-3.56 6.16	-3.56 5.82	-3.55 12.29
D_{max}	7.48	8.00	8.10	7.34		φ _{G10}	3.94	4.11	4.39	8.06
D_{max} D_{G1max}	0.75	1.16	1.33	0.30		Ψ_{G1o} Φ_s	8.63	8.68	8.89	16.50
vd _{max}	81.61	81.61	81.61	81.61		D_{os}	19.86	20.47	19.69	37.57
vd _{max} vd _{min}	30.30	23.77	23.77	23.77	60	D_{G1G2}	1.62	1.96	1.60	3.57
N_{G1}	7.00	7.00	6.00	6.00		L_{G1}	18.02	18.09	17.27	32.88
N_{G2}	7.00	6.00	8.00	8.00		L_{G2}	41.87	35.34	35.65	66.49
f_{G1}	12.26	12.68	17.28	15.88		$CRA_{obj}(MAX)$	4.85	4.12	4.69	4.96
	-10.13	-16.59	-44.18	-27.06		CRA _{obi} (MIN)	0.00	0.00	0.00	0.00
f_{G2}										
f_{G1o}	75.80	39.79	30.99	31.29		CRA_{img}	15.70	13.05	13.18	12.17
$egin{aligned} \mathbf{f}_{G1o} \ \mathbf{f}_{G2i} \end{aligned}$	75.80 -26.89	39.79 -92.10	30.99 -10.89	-9.44	65	D_{max}	15.89	6.97	7.09	12.95
f_{G1o}	75.80	39.79	30.99		65	CRA_{img} D_{max} D_{G1max}				

		-continued						-continued		
vd_{max}	81.61	81.61	81.61	81.61	•	BF	18.77	3.37	11.80	2.22
vd_{min}	23.88	23.88	23.88	23.88		NA	0.81	0.80	0.23	0.23
N_{G1}	5.00	6.00	6.00	6.00	5	β	-3.56	-3.54	-1.33	-1.33
N_{G2}	6.00	7.00	7.00	7.00	3	f	23.68	3.60	23.92	8.65
f_{G1}	7.65	7.39	7.62	14.27		φ _{G10}	7.14	6.93	35.10	19.15
f_{G2}	12.69 -34.83	13.38	13.36 -17.90	25.41 -30.20		Φ_s	50.87 83.01	20.59 30.70	25.14 86.05	10.01 32.23
f _{G10}	-34.83 -18.76	-16.54 -26.31	-17.90 -25.11	-30.20 -46.52		D _{os}	7.41	0.05	15.12	52.23 5.76
f_{G2i} f_{L1}	-16.70 -34.83	-26.51 -16.54	-23.11 -17.90	-30.20		D_{G1G2} L_{G1}	78.98	29.36	60.91	21.13
\mathbf{f}_{L2}	13.39	10.73	10.83	19.97	10	L_{G2}	211.47	62.19	87.29	42.85
f_{L3}	12.27	-43.67	-43.01	-80.66		CRA _{obj} (MAX)	1.62	2.41	5.17	4.99
f_{L4}	12.09	10.87	10.77	20.38		CRA _{obj} (MIN)	0.00	0.00	0.00	-3.49
f_{L5}	-6.63	9.43	9.67	17.89		CRA _{img}	5.18	23.15	24.74	24.88
f_{L6}	-8.89	-6.05	-6.14	-11.39		D_{max}	65.37	10.44	28.34	12.91
f_{L7}	12.18	-10.63	-10.73	-19.62		D_{G1max}	1.28	0.15	11.12	2.65
f_{L8}	14.00	13.45	13.32	24.00	15	vd_{max}	81.61	81.61	81.61	81.61
f_{L9}	19.50	12.93	13.02	24.17		vd_{min}	23.88	23.78	23.77	23.77
f_{L10}	-65.98	-146.69	-94.00	-241.88		N_{G1}	5.00	10.00	6.00	5.00
f_{L11}	-18.76	21.08	20.56	36.44		N_{G2}	7.00	9.00	8.00	8.00
f_{L12}	_	-47.76	-50.37	-101.22		f_{G1}	30.45	12.38	94.37	52.27
f_{L13}		-26.31	-25.11	-46.52	_	f_{G2}	60.53 -356.83	11.21 -63.28	20.77 -54.58	6.68 -34.14
	Example68	Example69	Example70	Example71	20	f_{G1o} f_{G2} i	-23.54	-9.39	-42.31	-21.94
	Exampleos	Lampicos	Lampie 70	Example / 1		f_{L1}	-356.83	-63.28	-54.58	-34.14
D_{oi}	198.0	89.0	96.5	94.7		\mathbf{f}_{L2}	56.88	69.53	37.85	24.01
Y_{obj}	5.9	3.1	3.1	3.1		f_{L3}	51.20	36.72	-95.51	22.73
Y	20.78	10.82	11.04	11.04		f_{L4}	67.75	25.98	39.47	33.81
L_{TL}	196.27	87.54	95.13	93.23		f_{L5}	-35.65	44.35	44.87	-10.90
L_L	192.17	84.29	91.83	89.95	25	f_{L6}	-47.30	-101.97	-19.47	-18.96
WD	1.76	1.43	1.35	1.42		f_{L7}	62.19	32.96	-38.56	17.44
BF	4.10	3.25	3.30	3.29		f_{L8}	64.81	-25.57	43.51	24.71
NA	0.60	0.59	0.62	0.60		f_{L9}	-115.85	22.34	64.36	29.65
β	-3.51	-3.51	-3.55	-3.53		f_{L10}	251.10	-22.63	67.19	-29.20
f	7.51	3.49	3.98	3.86	20	f_{L11}	51.88	64.58	-95.92	29.95
Φ _{G10}	13.42	7.46	7.64	7.59	30	f_{L12}	-23.54	29.63	62.16	-27.20
Φ_s	30.89 67.45	13.92 30.28	15.10 29.05	14.83 30.50		f_{L13}	_	-16.59	-143.67 -42.31	-21.94
D_{os}	1.97	1.21	29.03 0.67	0.31		$f_{L14} \\ f_{L15}$	_	36.16 83.99	-42.31 —	_
D_{G1G2}						¹ L15				
L_{G1}	62.16 128.04	26.55 56.54	27.04 64.12	27.74 61.90		f_{L16}	_	21.08 -12.32	_	
L_{G2}	128.04	56.54	64.12	61.90	35	f_{L17}	_	-12.32	_	_
L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN)					35	$f_{L17} \\ f_{L18}$			_ _ _	
L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN)	128.04 4.70	56.54 4.94	64.12 4.99	61.90 5.01	35	f_{L17}	_ _ _	-12.32 26.62		
$\begin{array}{c} \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj}\left(\mathbf{MAX}\right) \\ \mathbf{CRA}_{obj}\left(\mathbf{MIN}\right) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \end{array}$	128.04 4.70 0.00 24.79 16.44	56.54 4.94 0.00 25.00 9.47	64.12 4.99 0.00 20.83 10.91	61.90 5.01 0.00 22.04 10.39	35	$f_{L17} \\ f_{L18}$	Example76	-12.32 26.62	Example78	
$\begin{array}{l} \mathbf{L}_{G2} \\ \mathbf{CRA}_{obj}\left(\mathbf{MAX}\right) \\ \mathbf{CRA}_{obj}\left(\mathbf{MIN}\right) \\ \mathbf{CRA}_{img} \\ \mathbf{D}_{max} \\ \mathbf{D}_{G1max} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98	56.54 4.94 0.00 25.00 9.47 0.50	64.12 4.99 0.00 20.83 10.91 1.05	61.90 5.01 0.00 22.04 10.39 1.92	35	$f_{L17} \\ f_{L18} \\ f_{L19}$	Example76	-12.32 26.62 -9.39 Example77		Example79
$\begin{array}{l} L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61	56.54 4.94 0.00 25.00 9.47 0.50 81.61	64.12 4.99 0.00 20.83 10.91 1.05 81.61	61.90 5.01 0.00 22.04 10.39 1.92 81.61	35	f _{L17} f _{L18} f _{L19}	Example 76	-12.32 26.62 -9.39 Example77	38.9	Example79
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78	35	f_{L17} f_{L18} f_{L19} f_{Doi} Y_{obj}	Example 76 60.0 5.6	-12.32 26.62 -9.39 Example77 42.3 4.0	38.9 3.6	Example79 70.0 2.2
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00		f _{L17} f _{L18} f _{L19} D _{oi} Y _{obj} Y	Example 76 60.0 5.6 7.46	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33	38.9 3.6 4.75	Example79 70.0 2.2 4.92
$\begin{array}{l} L_{G2} \\ CRA_{obj} \left(MAX \right) \\ CRA_{obj} \left(MIN \right) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00		$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{TL} \end{array}$	Example 76 60.0 5.6 7.46 55.44	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54	38.9 3.6 4.75 36.46	Example79 70.0 2.2 4.92 54.21
$\begin{array}{l} L_{G2} \\ CRA_{obj} \left(MAX \right) \\ CRA_{obj} \left(MIN \right) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G2} \\ f_{G1} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53		$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ Y \\ L_{L} \\ L_{L} \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43	38.9 3.6 4.75 36.46 33.86	To.0 2.2 4.92 54.21 51.58
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50		$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{IL} \\ L_{L} \\ \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77	38.9 3.6 4.75 36.46 33.86 2.40	70.0 2.2 4.92 54.21 51.58 15.80
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11	38.9 3.6 4.75 36.46 33.86 2.40 2.60	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98		$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y_{L}_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \end{array}$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11	38.9 3.6 4.75 36.46 33.86 2.40 2.60	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \end{array}$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{7L} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \Phi_{G1o} \\ \Phi_{s} \end{array}$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66	To.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57
$\begin{array}{l} L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1i} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{\sigma 1o} \\ \phi_{s} \\ D_{\sigma e} \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ Vd_{max} \\ Vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{Gs} \\ D_{Gs} \\ D_{Gs} \\ \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{min} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L5} \\ f_{L5} \\ f_{L6} \\ f_{L7} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55
$\begin{array}{l} L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L6} \\ f_{L6} \\ f_{L7} \\ f_{L8} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06
$\begin{array}{l} L_{G2} \\ CRA_{obj}(MAX) \\ CRA_{obj}(MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25	38.9 3.6 4.75 36.46 33.86 2.40 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L9} \\ f_{L10} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{IL} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ Vd_{max} \\ Vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L10} \\ f_{L10} \\ f_{L11} \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42	40	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{G3} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MIN) \\ CRA_{img} \end{array}$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L22} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L21} \\ f_{L11} \\ f_{L21} \\ f_{L11} \\ f_{L2} \\ f_{L11} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L2} \\ f_{L11} \\ f_{L2} \\ f_{L11} \\ f_{L2} \\ f_{L11} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L10} \\ f_{L11} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L11} \\ f_{L2} \\ f_{L13} \\ f_{L11} \\ f_{L21} \\ f_{L21} \\ f_{L3} \\ f_{L41} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L10} \\ f_{L111} \\ f_{L111} \\ f_{L111} \\ f_{L112} \\ f_{L111} \\ f_{L111} \\ f_{L112} \\ f_{L111} \\ f_{L112} \\ f_{L113} \\ f_{L113} \\ f_{L144} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ Vd_{max} \\ Vd_{max} \\ \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ f_{L14} \\ f_{L15} \\ f_{L14} \\ f_{L15} \\ f_{L16} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{Os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{GImax} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00	38.9 3.6 4.75 36.46 33.86 2.40 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ f_{L14} \\ f_{L15} \\ f_{L14} \\ f_{L15} \\ f_{L16} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77 -25.80	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 -	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98	40 45 50	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02
$\begin{array}{l} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ f_{L14} \\ f_{L15} \\ f_{L14} \\ f_{L15} \\ f_{L16} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40	45	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 8.00 18.20 5.06	38.9 3.6 4.75 36.46 33.86 2.40 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29
$\begin{array}{c} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G1o} \\ f_{G2i} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ f_{L14} \\ f_{L15} \\ f_{L15} \\ f_{L16} \\ f_{L17} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77 -25.80 Example 72	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16 Example73	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 — Example74	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98 Example 75	40 45 50	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{s} \\ D_{os} \\ D_{GIG2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{o$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32 -24.61	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20 5.06 -15.40	38.9 3.6 4.75 36.46 33.86 2.40 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26 4.49 -13.03	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29 19.51
$\begin{array}{c} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77 -25.80 Example 72	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16 Example73	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 — Example74	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98 Example75	40 45 50	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{IL} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi \\ G1o \\ \phi \\ s \\ D_{os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{bing} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{max} \\ vd_{max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ f_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ \end{array}$	Example76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32 -24.61 -11.70	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20 5.06 -15.40 -7.84	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26 4.49 -13.03 -7.67	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29 19.51 -20.20
$\begin{array}{c} L_{G2} \\ CRA_{obj} (MAX) \\ CRA_{obj} (MIN) \\ CRA_{obj} (MIN) \\ CRA_{img} \\ D_{max} \\ D_{G1max} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{G1o} \\ f_{G2} \\ f_{L1} \\ f_{L2} \\ f_{L3} \\ f_{L4} \\ f_{L5} \\ f_{L6} \\ f_{L7} \\ f_{L8} \\ f_{L9} \\ f_{L10} \\ f_{L10} \\ f_{L11} \\ f_{L12} \\ f_{L13} \\ f_{L14} \\ f_{L15} \\ f_{L15} \\ f_{L15} \\ f_{L15} \\ f_{L16} \\ f_{L17} \\ \end{array}$	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77 -25.80 Example 72	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16 Example73	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 — Example74 186.7 16.3	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98 Example75 78.1 8.1	40 45 50	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \hline \\ D_{oi} \\ Y_{obj} \\ Y \\ L_{TL} \\ L_{L} \\ WD \\ BF \\ NA \\ \beta \\ f \\ \phi_{G1o} \\ \phi_{s} \\ D_{Os} \\ D_{G1G2} \\ L_{G1} \\ L_{G2} \\ CRA_{obj} (MIN) \\ CRA_{obj} (MIN) \\ CRA_{obj} (MIN) \\ RA_{img} \\ D_{Gimax} \\ vd_{max} \\ vd_{min} \\ N_{G1} \\ N_{G2} \\ f_{G1} \\ f_{G2} \\ f_{G1o} \\ f_{G2i} \\ f_{G1o} \\ f$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32 -24.61 -11.70 -24.61	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20 5.06 -15.40 -7.84 -15.40	38.9 3.6 4.75 36.46 33.86 2.40 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26 4.49 -13.03 -7.67 -13.03	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29 19.51 -20.20 19.51
L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{obj} (MIN) CRA _{img} D _{max} D _{G1max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1} f _{G2} f _{G1} f _{G2} f _{G1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L11} f _{L12} f _{L13} f _{L14} f _{L15} f _{L13} f _{L14} f _{L15} f _{L15} f _{L16} f _{L11} f _{L12} f _{L116} f _{L116} f _{L117} f _{L116} f _{L117} f _{L115} f _{L116} f _{L117}	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77 -25.80 Example 72	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16 Example73	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 - Example74	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98	40 45 50	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32 -24.61 -11.70 -24.61 12.51	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20 5.06 -15.40 -7.84 -15.40 9.81	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26 4.49 -13.03 -7.67 -13.03 8.36	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29 19.51 -20.20 19.51 -30.65
L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{obj} (MIN) CRA _{img} D _{max} D _{G1max} vd _{max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1o} f _{G2i} f _{L1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L10} f _{L10} f _{L11} f _{L12} f _{L13} f _{L14} f _{L15} f _{L15} f _{L16} f _{L11} f _{L12} f _{L13} f _{L14} f _{L15} f _{L16} f _{L17} f _{L16} f _{L17} f _{L16} f _{L17} f _{L17} f _{L16} f _{L17} f _{L17}	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -25.80 Example72 317.8 2.2 7.93 316.63	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16 Example73	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 Example74 186.7 16.3 21.63 175.11	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98 — Example75 78.1 8.1 10.82 71.96	40 45 50 55	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32 -24.61 -11.70 -24.61 12.51 -19.58	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20 5.06 -15.40 -7.84 -15.40 9.81 -25.65	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26 4.49 -13.03 -7.67 -13.03 8.36 -22.64	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 31.157 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29 19.51 -20.20 19.51 -30.65 25.01
L _{G2} CRA _{obj} (MAX) CRA _{obj} (MIN) CRA _{obj} (MIN) CRA _{img} D _{max} D _{G1max} vd _{min} N _{G1} N _{G2} f _{G1} f _{G2} f _{G1} f _{G2} f _{G1} f _{G2} f _{G1} f _{L2} f _{L3} f _{L4} f _{L5} f _{L6} f _{L7} f _{L8} f _{L9} f _{L10} f _{L11} f _{L12} f _{L13} f _{L14} f _{L15} f _{L13} f _{L14} f _{L15} f _{L15} f _{L16} f _{L11} f _{L12} f _{L116} f _{L116} f _{L117} f _{L116} f _{L117} f _{L115} f _{L116} f _{L117}	128.04 4.70 0.00 24.79 16.44 0.98 81.61 23.78 8.00 9.00 26.67 23.91 -23.95 -25.80 -23.95 47.51 34.71 92.60 40.59 -37.87 35.01 -40.29 95.43 63.05 -34.09 69.13 193.42 40.14 -26.47 -699.77 -25.80 Example 72	56.54 4.94 0.00 25.00 9.47 0.50 81.61 23.78 8.00 9.00 12.77 8.21 -13.88 -9.16 -13.88 26.64 17.87 49.61 19.99 -20.18 17.32 -14.74 32.60 27.51 -12.99 30.92 64.33 18.45 -12.40 33.28 -9.16 Example73	64.12 4.99 0.00 20.83 10.91 1.05 81.61 23.78 8.00 8.00 13.05 7.57 -23.63 -12.56 -23.63 49.63 16.80 50.11 21.35 -17.12 15.68 -13.72 29.49 30.46 -15.53 33.80 78.99 20.19 -13.04 -12.56 - Example74	61.90 5.01 0.00 22.04 10.39 1.92 81.61 23.78 7.00 8.00 13.53 7.50 -18.12 -11.98 -18.12 31.61 14.76 19.71 -17.88 15.83 -13.95 24.32 36.34 -15.11 33.42 80.48 20.12 -14.40 -11.98	40 45 50	$\begin{array}{c} f_{L17} \\ f_{L18} \\ f_{L19} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Example 76 60.0 5.6 7.46 55.44 50.94 4.57 4.49 0.23 -1.34 7.83 12.21 7.44 26.76 3.57 18.92 28.45 5.18 0.00 24.82 11.11 2.70 81.61 23.77 6.00 8.00 32.52 6.32 -24.61 -11.70 -24.61 12.51	-12.32 26.62 -9.39 Example77 42.3 4.0 5.33 39.54 36.43 2.77 3.11 0.22 -1.34 5.46 8.66 5.16 19.94 3.42 13.99 19.01 5.25 0.00 25.37 5.30 1.82 81.61 23.77 6.00 8.00 18.20 5.06 -15.40 -7.84 -15.40 9.81	38.9 3.6 4.75 36.46 33.86 2.40 2.60 0.23 -1.33 4.88 7.73 4.66 18.00 2.99 12.86 18.02 5.38 0.00 25.13 4.58 1.35 81.61 23.77 6.00 8.00 16.26 4.49 -13.03 -7.67 -13.03 8.36	Example79 70.0 2.2 4.92 54.21 51.58 15.80 2.63 0.38 -2.20 5.02 16.73 11.57 32.14 0.96 15.55 35.06 3.01 0.00 19.17 8.48 0.10 81.61 23.77 6.00 7.00 14.02 919.29 19.51 -20.20 19.51 -30.65

		-continued						-continued		
f_{L6}	-6.06	-4.96	-4.28	-10.74		D_{G1max}	0.35	0.05	0.05	0.18
f_{L7}	-11.85	-10.26	-8.65	-10.27		vd _{max}	81.54	81.61	81.61	81.61
f_{L8}	13.37	10.27	9.03	13.10	-	vd_{min}	30.30	23.88	23.88	23.88
f_{L9}	20.64	16.03	14.04	22.47	5	N_{G1}	4.00	5.00	5.00	5.00
f_{L10}	21.90	16.67	14.68	-26.66		N_{G2}	6.00	6.00	6.00	6.00
f_{L11}	-29.72	-24.27	-20.66	12.62		f_{G1}	4.84	5.13	5.68	3.72
f_{L12}	20.98	15.70	13.61	-10.03		f_{G2}	6.71	8.69	7.57	4.86
f_{L13}	-122.15	-46.89	-27.17	-20.20		f_{G1o}	5.76	-20.67	-9.49	-23.50
f_{L14}	-11.70	-7.84	-7.67	_	10	f_{G2i}	-5.67 5.76	-18.30 -20.67	-16.04 -9.49	-12.20 -23.50
	Example80	Example81	Example82	Example83	10	$egin{aligned} \mathbf{f}_{L1} \ \mathbf{f}_{L2} \end{aligned}$	-28.93	7.74	7.53	6.67
	Exampleo	Exampleor	Example 02	Exampleos		f_{L3}	5.78	6.64	5.45	5.74
D_{oi}	42.0	42.0	42.0	95.0		f_{L4}	-4.33	5.42	6.45	7.78
Y_{obj}^{oi}	1.9	1.9	1.9	8.2		f_{L5}	4.34	-3.10	-3.50	-4.03
Y	3.87	3.87	3.87	10.82		f_{L6}	-5.80	-3.34	-3.72	-5.88
L_{TL}	39.50	39.51	39.51	88.69	15	f_{L7}	-39.03	4.70	5.20	6.11
L_L	37.80	36.70	36.70	86.69		f_{L8}	130.77	7.31	6.96	8.22
WD	2.50	2.50	2.50	6.33		f_{L9}	4.80	-4.20	-4.61	-20.92
BF	1.70	2.81	2.81	2.00		f_{L10}	-5.67	8.00	7.57	25.26
NA e	0.32 -2.00	0.32 -2.00	0.32 -2.00	0.33 -1.32		f_{L11}	_	-18.30	-16.04	-12.20
β f	3.72	4.27	4.22	9.91			Example88	Example89	Example90	Example91
ϕ_{G1o}	4.74	4.79	4.79	17.51	20		Litampiedo	Litampicos	Lxample 50	Lxample >1
ϕ_s	4.35	4.32	4.41	16.65		D_{oi}	31.5	53.0	59.0	57.0
D_{os}	16.30	16.95	16.10	46.23		\mathbf{Y}_{obj}^{-oi}	0.5	0.3	1.4	1.1
D_{G1G2}	2.34	2.31	2.42	7.49		Y	2.30	2.30	2.82	2.25
L_{GI}	12.41	13.22	12.19	33.79		L_{IL}	30.83	52.83	55.01	53.01
L_{G2}	23.05	21.17	22.09	45.40	25	L_L	26.99	37.38	50.04	48.35
$CRA_{obj}(MAX)$	5.09	5.06	5.07	5.49	25	WD	0.66	0.21	4.00	4.00
CRA _{obj} (MIN)	0.00	0.00	0.00	0.00		BF	3.84	15.45	4.97	4.66
CRA_{img}	21.91	21.91	21.76	25.15		NA	0.75	0.95	0.39	0.41
D_{max}	4.64	4.93	5.73	19.80		β	-4.18	-8.37	-2.04	-2.04
D_{G1max}	0.46	0.45	0.28	6.49		f	1.99	2.62	10.15 5.57	9.96
vd _{max}	81.61 23.77	81.61 23.77	81.61 23.77	81.61 23.77	30	φ _{G10}	2.11 5.46	1.51 8.61	7.00	5.37 7.05
$\mathrm{vd}_{min} \ \mathrm{N}_{G1}$	6.00	6.00	6.00	7.00	50	Φ_s D_{os}	8.62	11.27	27.30	25.23
N_{G2}	7.00	7.00	6.00	8.00		D_{G1G2}	0.16	0.49	2.28	2.12
f_{G1}	7.77	7.39	8.00	29.25		L_{G1}	7.80	10.95	21.12	19.21
f_{G2}	5.31	6.90	5.81	12.79		L_{G2}	19.03	25.94	26.64	27.02
f_{G1o}	-49.08	-38.01	-394.66	-43.59		$CRA_{obj}(MAX)$	1.33	0.00	2.29	0.88
f_{G2i}	-9.73	-7.49	-7.20	-28.44	35	$CRA_{obi}(MIN)$	0.00	-1.04	0.00	0.00
f_{L1}	-49.08	-38.01	-394.66	-43.59		CRA_{img}	15.86	6.11	5.62	5.61
f_{L2}	7.81	8.01	8.35	20.83		D_{max}	3.54	3.75	4.23	4.14
f_{L3}	-12.93	-8.77	-11.94	-24.58		D_{G1max}	0.05	0.05	2.85	3.46
f_{L4}	10.12 6.12	7.77 7.51	10.11 7.13	36.17 31.43		vd _{max}	81.61 23.88	81.61 23.88	94.93 23.78	94.93 23.78
$egin{aligned} \mathbf{f}_{L5} \ \mathbf{f}_{L6} \end{aligned}$	-3.71	-4.59	-4.14	23.02		$\mathrm{vd}_{min} \ \mathrm{N}_{G1}$	5.00	5.00	6.00	6.00
f_{L7}	-9.00	-10.92	-8.71	-13.86	40	N_{G2}	6.00	7.00	7.00	7.00
f_{L8}	8.86	13.97	8.92	-25.64		f_{G1}	3.45	3.49	9.19	8.65
f_{L9}	10.55	11.01	9.82	38.61		f_{G2}	4.02	6.12	14.39	11.93
f_{L10}	-21.47	68.51	-14.82	35.83		f_{Glo}	-16.97	-188.41	-5.35	-5.97
f_{L11}	13.49	-18.39	13.77	45.75		f_{G2i}	-8.79	-13.18	10.98	17.06
f_{L12}	-17.07	14.10	-7.20	-62.24	45	f_{L1}	-16.97	-188.41	-5.35	-5.97
f_{L13}	-9.73	-7.49	_	34.74	40	f_{L2}	6.44	7.75	7.52	7.45
f_{L14}	_	_	_	-31.23		f_{L3}	5.26	6.11	15.14	14.61
f_{L15}				-28.44		f_{L4}	6.83 -4.18	9.89 -6.16	16.17 22.58	12.63 65.83
	Example84	Example85	Example86	Example87		f_{L5} f_{L6}	-4.16 -5.93	-8.03	-6.08	-6.36
	Liampico	Lxampico5	Liampiedo	Example 67		f_{L7}	5.06	9.89	-8.66	-9.70
D_{oi}	28.4	35.3	33.0	40.0	50	f_{L8}	7.73	12.25	8.05	7.95
\mathbf{Y}_{obj}^{-oi}	1.1	1.1	1.2	0.5		f_{L9}	-10.04	16.32	9.42	9.41
Y	2.82	2.86	2.30	2.23		f_{L10}	12.64	-13.51	-5.50	-5.29
L_{TL}	24.89	31.65	29.34	39.37		f_{L11}	-8.79	20.30	9.06	8.00
L_L	18.91	28.14	26.24	33.75		f_{L12}	_	-13.18	-7.93	-9.17
WD	3.49	3.60	3.70	0.65		f_{L13}	_	_	10.98	17.06
BF	5.98	3.51	3.10	5.63	55					
NA	0.42	0.40	0.40	0.74			Example92	Example93	Example94	Example95
β	-2.54	-2.58	-1.99	-4.18		D.	04.0		01.0	10.0
f	5.60	6.09	5.65	2.80		D_{oi}	81.0	57.0	81.0	42.0
Ф _{G10}	6.27	4.72	4.52	2.14		Y_{obj}	0.5	1.1	0.5	1.9
φ _s	3.75	3.92	4.29	5.92	60	Y	2.25	2.25	2.25	3.87
D_{os}	11.35	11.28	11.56	9.99	00	L _{TL}	80.01	53.00	80.01	39.99
D_{G1G2}	0.72 6.51	1.07	1.13 7.36	0.66 9.02		$egin{array}{c} { m L}_L \ { m WD} \end{array}$	75.35 1.00	48.35 4.00	74.89	38.29
L_{G1}	11.68	7.17 19.90	7.36 17.75	9.02 24.07		BF	4.66	4.00	1.00 5.13	2.01 1.70
L _{G2}	0.57	3.42	4.40	0.56		NA	4.00 0.74	4.63 0.40	0.69	0.32
CRA (MIN)	0.37	3.42 0.00	0.00	0.36		β	-4.09	-2.04	-4.09	-2.00
CRA_{obj} (MIN) CRA_{img}	9.96	10.12	10.38	10.98	65	f	6.29	9.83	6.84	3.75
D_{max}	2.78	4.34	3.45	3.51		ϕ_{G1o}	3.08	5.24	2.90	4.91
~max	2.70	T.J.T	5.75	3.31		¥G10	5.00	J.4-T	2.20	1.71

		-continued		
Φ_s	8.97	6.91	8.13	5.58
D_{os}	25.76	25.31	25.47	13.92
D_{G1G2}	2.90	2.07	3.59	1.16
L_{G1}	21.96	19.34	21.84	11.81
L_{G2}	50.49	26.94	49.45	25.32
$CRA_{obj}(MAX)$	0.00	0.99	0.00	1.21
CRA _{obi} (MIN)	-1.16	0.00	-2.31	0.00
CRA_{img}	5.61	5.61	5.58	23.82
D_{max}	17.45	4.13	18.98	4.73
$DG1_{max}$	0.10	3.79	3.68	2.81
vd_{max}	81.61	94.95	81.61	81.61
vd_{min}	23.78	23.78	23.78	23.77
N_{G1}	6.00	6.00	5.00	7.00
N_{G2}	6.00	7.00	6.00	7.00
f_{G1}	5.80	8.93	5.58	8.64
f_{G2}	15.76	11.67	18.54	5.35
f_{G1o}	-12.63	-6.06	13.76	28.96
f_{G2i}	-64.25	16.31	-53.92	-10.77
f_{L1}	-12.63	-6.06	13.76	28.96
f_{L2}	8.98	7.53	25.11	7.91
f_{L3}	31.87	14.85	29.18	6.66
f_{L4}	30.81	13.01	8.68	-10.48
f_{L5}	9.29	66.65	-5.84	-7.74
f_{L6}	-6.10	-6.38	-7.71	9.09
f_{L7}	-10.23	-10.84	9.91	11.82
f_{L8}	12.17	8.38	24.46	-61.10
f_{L9}	19.79	9.37	-27.09	13.27
f_{L10}	-35.91	-5.19	20.16	-9.57
f_{L11}	24.54	8.16	-53.92	-10.77
f_{L12}	-64.25	-9.11	_	_
f_{L13}	_	16.31	_	_

	Example96
D_{oi}	42.0
\mathbf{Y}_{obj}	1.9
Y	3.87
$\mathrm{L}_{T\!L}$	40.00
L_L	38.30
WD	2.00
BF	1.70
NA	0.32
β	-2.00
f	3.71
ϕ_{G1o}	4.88
Φ_s	5.76
D_{os}	14.98
D_{G1G2}	1.17
L_{G1}	12.88
L_{G2}	24.25
$CRA_{obj}(MAX)$	1.23
CRA _{obj} (MIN)	0.00
CRA _{img}	23.29
D_{max}	4.22
D_{G1max}^{max}	2.00
vd _{max}	81.61
vd_{min}	23.77
N_{G1}	8.00
N_{G2}	7.00
f_{G1}	8.77
f_{G2}	5.85
f_{GI_o}	42.78
\mathbf{f}_{G2i}	-11.46
\mathbf{f}_{L1}	42.78
\mathbf{f}_{L2}^{D1}	8.79
\mathbf{f}_{L3}^{L2}	38.11
\mathbf{f}_{L4}	7.09
\mathbf{f}_{L5}^{L4}	-13.77
f_{L6}^{L3}	-8.18
${ m f}_{L7}^{-L}$	9.73
\mathbf{f}_{L8}^{-L}	11.92
$\mathbf{f}_{L9}^{-L\circ}$	-61.27
f_{L10}	13.10
f_{L11}	-8.77
\mathbf{f}_{L12}	-11.46
-L12	==-:-3

FIG. **104** is a diagram showing a microscope which is an 65 optical instrument according to the present embodiment. A microscope **1** is a microscope of an upright type. As shown in

FIG. 104, the microscope 1 includes a main body 2, a stage 3, an image pickup section 4, an illuminating unit 5, an aiming knob 6, an optical system 7, and an image pickup element 8.

The main body 2 is provided with the stage 3, the image pickup section 4, and the aiming knob 6. A sample is placed on the stage 3. Movement of the stage 3 in an optical axial direction is carried out by the aiming knob 6. The stage 3 is moved by an operation (rotation) of the aiming knob 6, and accordingly, focusing with respect to the sample is possible.

For this, a moving mechanism (not shown in the diagram) is provided between the main body 2 and the stage 3.

The image pickup section **4** is provided with the illuminating unit **5**. The image pickup section **4** and the illuminating unit **5** are positioned above the stage **3**. An illuminating element **5***a* is disposed to be in a ring shape in the illuminating unit **5**. An LED is an example of the illuminating element **5***a*.

The optical system 7 and the image pickup element 8 are disposed at an interior of the image pickup section 4. The optical system according to the example 1 for instance, is used for the optical system 7. The optical system 7 includes an objective 7a (the lens unit Gf or the first lens unit) and a tube lens 7b (the lens unit Gr or the second lens unit). A front end of the objective 7a is positioned at a central portion of the illuminating unit 5.

25 Illuminating light is irradiated from the illuminating unit 5. In this case, the illumination is an epi-illumination. Light reflected from the sample travels through the optical system 7 and is incident on the image pickup element 8. A sample image (optical image) is formed on an image pickup surface of the image pickup element 8. The sample image is subjected to photoelectric conversion by the image pickup element 8, and accordingly, an image of the sample is achieved. The image of the sample is displayed on a display unit (not shown in the diagram). In such manner, an observer is able to observe the image of the sample.

Here, the microscope 1 includes the optical system 7 (the optical system according to the present embodiment). In this optical system 7, the numerical aperture on the image side is large, and various aberrations are corrected favorably. Therefore, in the microscope 1, various aberrations are corrected favorably, and a bright and sharp sample image is achieved.

In the example described above, the optical system was disposed in the image pickup section. However, the arrangement is not restricted to such an arrangement. For example, in an objective (the lens unit Gf or the first lens unit) for which, a parfocal distance is 75 mm, it is possible to dispose the optical system and the image pickup element of the present example in a frame member which holds lenses. In this case, it is possible to install the optical system according to the present embodiment to the revolver similarly as the existing objective lens. When such an arrangement is made, it is possible to use the existing objective lens (the lens unit Gf or the second lens unit) and the optical system according to the present embodiment upon switching over.

Moreover, the description has been made by using the example of the microscope as the optical instrument using the abovementioned optical system. However, the optical system according to the present invention is not restricted to the microscope, for example, the optical system according to the present invention is applicable to an electronic image pickup apparatus (a lens unit for a portable camera, a notebook computer, and a handheld information terminal) as an optical instrument.

Since the image pickup section 4 includes the image pickup element 8, it is possible to assume the image pickup section 4 as an image pickup apparatus. In this case, since a microscope 1 includes the image pickup section 4, the stage 3,

and the illuminating unit 5, it can be referred to as an image pickup system. In FIG. 104, the stage 3 is connected to the main body 2 via the aiming mechanism (aiming knob 6). However, the stage 3 may be installed directly on the main body without installing via a moving mechanism. By making 5 such an arrangement, it is possible to integrate the image pickup section 4 and the stage 3 via the main body 2.

FIG. 105 is a diagram showing a microscope which is the optical instrument of the present embodiment. A microscope 10 is a microscope of the upright type. Same reference numerals are assigned to components which are same as in the microscope 1 (FIG. 104), and description of such components is omitted.

An optical system 11 and the image pickup element 8 are disposed at the interior of the image pickup section 4. The 15 optical system according to the example 8 for instance, is used for the optical system 11. The optical system 11 includes a first lens unit 11a (or the lens unit Gf) and the second lens unit 11b (or the lens unit Gr).

In the microscope 1, the illuminating unit 5 has been provided toward the optical system 7. Whereas, in the microscope 10, an illuminating unit 12 is provided on an opposite side of the optical system 11, sandwiching the stage 3 between the illuminating unit 12 and the optical system 11. The illuminating unit 12 includes alight source section 13 and 25 a light guiding fiber 14.

The light source section 13 includes a light source such as a halogen lamp, a mercury lamp, a xenon lamp, an LED (light emitting diode), or a laser. Moreover, the light source section 13 includes a lens. Illuminating light emitted from the light 30 source is incident on an inlet end 15 of the light guiding fiber 14. The illuminating light incident on the light guiding fiber 14 is transmitted through the light guiding fiber 14, and is emerged from an exit end 16.

The exit end **16** of the light guiding member **14** is connected to the stage **3** by a holding mechanism (not shown in the diagram). Here, the exit end **16** of the light guiding fiber **14** is positioned on a lower surface of the stage **3**. Therefore, the illuminating light emerged from the exit end **16** is directed from a lower side of the stage **3** toward the optical system **11**, 40 and is irradiated to the sample. In this manner, transmitted illumination is carried out in the microscope **10**.

Here, the light guiding fiber 14 is held by the stage 3. However, the light guiding fiber 14 may be held by a means other than the stage 3. Moreover, the exit end 16 of the light 45 guiding member 14 may be positioned on an upper surface (the optical system 7 side) of the stage 3. By making such an arrangement, it is possible to carry out the epi-illumination in the microscope 10 similarly as in the microscope 1.

Transmitted light from the sample travels through the optical system 11 and is incident on the image pickup element 8. A sample image (an optical image) is formed on the image pickup surface of the image pickup element 8. The sample image is subjected to photoelectric conversion by the image pickup element 8, and accordingly, an image of the sample is achieved. The image of the sample is displayed on a display unit (not shown in the diagram). In such manner, the observer is able to observe the image of the sample.

The microscope 10 also includes the optical system 11 (the optical system according to the present embodiment). The 60 optical system 11 is an optical system in which aberrations are corrected favorably, while being an optical system having a short overall length, and has a high resolution because of the favorable correction of aberrations. Therefore, in the microscope 10, various aberrations are corrected favorably, and a 65 sample image in which, the microscopic structure is clear, is achieved. The illumination of the microscope 10 may be

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epi-illumination. Moreover, it is possible to make design modifications appropriately in an arrangement of members which form the microscope 10.

FIG. 106 is a diagram showing a microscope which is an optical instrument of the present embodiment. A microscope 20 is a microscope of an inverted type. The microscope 20 includes a main body 21, a stage 22, the image pickup section 4, an optical system 23, the image pickup element 8, an aiming knob 24, a transmitted illumination light source 25, a reflecting mirror 26, and a condenser lens 27.

Here, the optical system 23 and the image pickup element 8 are disposed at the interior of the image pickup section 4. For the optical system 23, an optical system such as the optical system according to the example 20 is used. The optical system 23 includes a first lens unit (or the lens unit Gf) 23a and a second lens unit (or the lens unit Gr) 23b.

The main body 21 is provided with the stage 22, the image pickup section 4, and the aiming knob 24. A sample is placed on the stage 22. Movement of the image pickup section 4 in the optical axial direction is carried out by the aiming knob 24. The image pickup section 4 is moved by an operation (rotation) of the aiming knob 24, and accordingly, focusing with respect to the sample is possible. For this, a moving mechanism (not shown in the diagram) is provided inside the main body 21, and the image pickup section 4 is held by the moving mechanism.

Moreover, the main body 21 is provided with the transmitted illumination light source 25, the reflecting mirror 26, and the condenser lens 27. The transmitted illumination light source 25, the reflecting mirror 26, and the condenser lens 27 are disposed above the stage 22. Illuminating light emitted from the transmitted illumination light source 25 is reflected at the reflecting mirror 26, and is incident on the condenser lens 27. The condenser lens 27 is positioned above an upper surface of the stage 22. Accordingly, illuminating light emerged from the condenser lens 27 is directed from an upper side of the stage 22 toward the optical system 23, and is irradiated to the sample. In such manner, the transmitted illumination is carried out in the microscope 20.

The microscope 20 also includes the optical system 23 (optical system according to the present embodiment). The optical system 23 is an optical system in which aberrations are corrected favorably, while being an optical system having a short overall length, and has a high resolution because of the favorable correction of aberrations. Therefore, in the microscope 20, various aberrations are corrected favorably, and a sample image in which, the microscopic structure is clear, is achieved. It is possible to make design modifications appropriately in an arrangement of members which form the microscope 20.

FIG. 107A and FIG. 107B are diagrams showing a microscope which is an optical instrument of the present embodiment. FIG. 107A is a diagram showing an arrangement of the microscope, and FIG. 107B is a diagram showing a state in which, a microscope 30 is fixed.

The microscope 30 is a microscope of a portable type. The microscope 30 includes a probe section 31, a control box 32, a light guiding fiber 33, a cable 34, the image pickup section 4, an optical system 35, the image pickup element 8, a light guiding body for illumination 36, and a light source 37.

The optical system **35** and the image pickup element **8** are disposed at the interior of the image pickup section **4**. For the optical system **35**, an optical system such as the optical system according to the example 61 is used. The optical system **35** includes a first lens unit (or the lens unit Gf), **35***a* and a second lens unit (or the lens unit Gr) **35***b*.

The probe section 31 and the control box 32 are connected by the light guiding fiber 33 and the cable 34. The control box 32 includes the light source 37 and a processing section (not shown in the diagram). The processing section processes a video signal from the probe section 31.

The probe section 31 is of a size that enables a user to hold the probe section 31 in a hand. The probe section 31 includes the image pickup section 4 and the light guiding body for illumination 36. The light guiding body for illumination 36 is disposed at an outer peripheral side of the image pickup section 4. The light guiding body for illumination 36 is optically connected to the light guiding fiber 33. Illuminating light emitted from the light source 37 is transmitted through the light guiding fiber 33, and is incident on the light guiding body for illumination 36. The illuminating light is transmitted through the light guiding body for illumination, and is emerged from the probe section 31. In such manner, the epi-illumination is carried out in the microscope 30.

Light reflected from the sample travels through the optical system **35** and is incident on the image pickup element **8**. A 20 sample image (an optical image) is formed on the image pickup surface of the image pickup element **8**. The sample image is subjected to photoelectric conversion by the image pickup element **8**, and accordingly, an image of the sample is achieved. The image of the sample is displayed on the display 25 unit (not shown in the diagram). In such manner, the observer is able to observe the image of the sample.

The probe section 31 is connected to the control box 32 by the light guiding fiber 33 and the cable 34. Therefore, it is possible to set a position and a direction of the probe 31 freely.

30 In this case, fixing of a posture (position and direction) of the probe section 31 is to be carried out by hands of the observer. However, in fixing by the hands of the observer, sometimes there is no sufficient stability.

For stabilizing the posture (position and direction) of the 35 (20) are satisfied: probe section 31, it is preferable to hold the probe section 31 by a mount 38 as shown in FIG. 107B. By doing so, it is possible to stabilize the posture of the probe section 31. $\beta \le -1.1$

The mount 38 is provided with an aiming knob 39. Movement of the probe section 31 (image pickup section 4) in the 40 optical axial direction is carried out by the aiming knob 39. The probe section 31 is moved by an operation (rotation) of the aiming knob 39, and accordingly, focusing with respect to the sample is possible. For this, a moving mechanism (not shown in the diagram) is provided inside the mount 38.

The microscope 30 also includes the optical system 35 (optical system according to the present embodiment). The optical system 35 is an optical system in which aberrations are corrected favorably, while being an optical system having a short overall length, and has a high resolution because of the favorable correction of aberrations. Therefore, in the microscope 30, various aberrations are corrected favorably, and a sample image in which, the microscopic structure is clear, is achieved. It is possible to make design modifications appropriately in an arrangement of members which form the microscope 30.

In each of the microscope 1, the microscope 10, the microscope 20, and the microscope 30, any optical system from among the optical systems according to the example 1 to the example 96 can be used.

In such manner, the present invention may have various modified examples without departing from the scope of the invention. Shapes and the number of lenses are not restricted to the shapes and the number indicated in the examples described heretofore. A lens which is not shown in the diagrams of the examples described heretofore, and which essentially has no refractive power may be disposed.

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According to the present invention, it is possible to provide an optical system in which, an aberration is corrected favorably, and the overall length is short while having a high resolution due to the favorable aberration correction, and an image pickup apparatus, and an image pickup system in which such optical system is used. Moreover, according to the present invention, it is possible to provide an optical system in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably, and an optical instrument in which, such optical system is used.

The present invention also includes the following inventions in addition to the abovementioned inventions. (Appended Mode 1-1)

An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit having a positive refractive power, which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expressions (15), (16), (19), and (20) are satisfied:

$$\beta \leq -1.1 \tag{15}$$

$$0.0 < NA$$
 (16)

$$1.0 < WD/BF \tag{19}$$

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 4.0$$
 (20)

where,

β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the optical system,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens,

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the image,

 Y_{obj} denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

(Appended Mode 1-2)

The optical system according to appended mode 1-1, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31) is satisfied:

$$0.1 < L_{GI}/L_{G2} < 1.5$$
 (31)

where

60

 ${\cal L}_{G1}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\cal L}_{G2}$ denotes a distance on the optical axis from an object-side surface of the second object-side lens up to an image side surface of the second image-side lens.

The optical system according to one of appended modes 1-1 and 1-2, wherein the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where.

 D_{os} denotes a distance on the optical axis from the object up to the stop, and

 \mathbf{D}_{ot} denotes a distance on the optical axis from the object up to the image.

(Appended Mode 1-4)

The optical system according to one of appended modes 1-1 to 1-3, wherein the following conditional expression (23) 15 is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where.

 ${\rm L}_L$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens, and

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 1-5)

The optical system according to one of appended modes 1-1 to 1-4, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where,

 ${\rm D}_{os}$ denotes the distance on the optical axis from the object 35 up to the stop, and

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 1-6)

The optical system according to one of appended modes 1-1 to 1-5, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21) 45

where.

 D_{max} denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system,

 ϕ_s denotes the diameter of the stop.

(Appended Mode 1-7)

The optical system according to one of appended modes 1-1 to 1-6, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where,

 ${\rm L}_L$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side 60 surface of the second image-side lens,

 \mathbf{D}_{ot} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. 286

(Appended Mode 1-8)

The optical system according to one of appended modes 1-1 to 1-7, wherein

the first lens unit includes a first image-side lens which is 5 disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
 = 0.39×WD/BF < 1.8 (57)

where,

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop,

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 1-9)

The optical system according to one of appended modes 1-1 to 1-8, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

25

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

 ${\rm L}_{L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 1-10)

The optical system according to one of appended modes 1-1 to 1-9, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} < 0.5 \tag{36}$$

where,

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 D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system.

 CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.

(Appended Mode 1-11)

An optical system according to one of appended modes 1-1 to 1-10, wherein

a conjugate image of an object is formed by the first lens unit, and

a final image of the object is formed by the second lens unit, and

the following conditional expression (18) is satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C})) / \epsilon_d < 30$$
(18)

where

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a

C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the 5 image point P_{G_1} is let to be an object point of the second lens

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, 10 ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the 15 object point of the second lens unit,

 f_{G2C} denotes a focal length for the C-line of the second lens unit, and

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the 20 optical system, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object point and a virtual image point.

(Appended Mode 1-12)

The optical system according to one of appended modes 1-1 to 1-11, wherein the following conditional expression (22) is satisfied:

$$0.01 \le D_{G1max}/\phi_s \le 2.0$$
 (22)

where,

D_{G1max} denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens

 ϕ_s denotes the diameter of the stop.

(Appended Mode 1-13)

The optical system according to one of appended modes 1-1 to 1-12, wherein the following conditional expression (24) is satisfied:

$$0.01 < 1/\nu d_{min} - 1/\nu d_{max}$$
 (24)

where.

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

 vd_{max} denotes a largest Abbe's number from among 45 Abbe's numbers for lenses forming the optical system. (Appended Mode 1-14)

The optical system according to one of appended modes 1-1 to 1-13, wherein the following conditional expression (26) is satisfied:

$$0.95 < \phi_{G1o}/(2 \times Y/|\beta|) \tag{26}$$

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical 55 system, and

 β denotes the imaging magnification of the optical system. (Appended Mode 1-15)

The optical system according to one of appended modes 1-1 to 1-14, wherein the following conditional expression 60 (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

BF denotes the distance on the optical axis from the image- 65 side surface of the second image-side lens up to the image,

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Y denotes the maximum image height in the overall optical

(Appended Mode 1-16)

The optical system according to one of appended modes 1-1 to 1-15, wherein the following conditional expression (29) is satisfied:

$$-0.2 < \phi_{G1o}/R_{G1o} < 3.0$$
 (29)

 ϕ_{G1o} denotes the effective diameter of the object-side surface of the first object-side lens, and

 R_{G1o} denotes a radius of curvature of the object-side surface of the first object-side lens.

(Appended Mode 1-17)

The optical system according to one of appended modes 1-1 to 1-16, wherein

the second lens unit includes four lenses, and

at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and

an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, is a convex surface that is convex toward the object side. (Appended Mode 1-18)

The optical system according to one of appended modes 1-1 to 1-17, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image side, and

a distance of two lenses positioned on two sides of the stop 30 is fixed, and

the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

 D_{G1G2} denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 1-19)

The optical system according to one of appended modes 1-1 to 1-18, wherein the following conditional expression (32) is satisfied:

$$0.1 < L_{G1s} / L_{sG2} < 1.5$$
 (32)

 L_{G1s} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens. (Appended Mode 1-20)

The optical system according to one of appended modes 1-1 to 1-19, wherein the following conditional expression (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0 \tag{33}$$

where.

 ϕ_{G1max} denotes a maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter of lenses in the second lens unit. (Appended Mode 1-21)

The optical system according to one of appended modes 1-1 to 1-20, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop, and

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the 5 image-side surface of the first image-side lens.

(Appended Mode 1-22)

The optical system according to one of appended modes 1-1 to 1-21, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5$$
 (36)

where.

 ${\rm D}_{ENP}$ denotes the distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system,

 ${\rm CRA}_{obj}$ denotes the maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes the maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 1-23)

The optical system according to one of appended modes 1-1 to 1-22, wherein

the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first object-side lens, and

at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

(Appended Mode 1-24)

The optical system according to one of appended modes 1-1 to 1-23, wherein the first object-side lens has a positive refractive power.

(Appended Mode 1-25)

The optical system according to one of appended modes 1-1 to 1-24, wherein the following conditional expression (37) is satisfied:

$$0.05 < f_{G1}/f$$
 (37)

where.

 ${\bf f}_{G1o}$ denotes a focal length of the first object-side lens, and f denotes a focal length of the overall optical system.

(Appended Mode 1-26)

The optical system according to one of appended modes 1-1 to 1-25, wherein an object-side surface of the first object-side lens is convex toward the object side.

(Appended Mode 1-27)

The optical system according to one of appended modes 1-1 to 1-26, wherein the following conditional expression (38) is satisfied:

$$0.02 < R_{G1} / WD$$
 (38)

where.

 R_{G1o} denotes the radius of curvature of the object-side surface of the first object-side lens, and

WD denotes the distance on the optical axis from the object up to the object-side side surface of the first object-side lens.

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(Appended Mode 1-28)

The optical system according to one of appended modes 1-1 to 1-27, wherein

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 1-29)

The optical system according to one of appended modes 15 1-1 to 1-28, wherein

an image-side surface of the second image-side lens is concave toward the image side, and

the following conditional expression (39) is satisfied:

$$0.1 < R_{G2i/BF}$$
 (39)

where,

 R_{G2i} denotes a radius of curvature of the image-side surface of the second image-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 1-30)

The optical system according to appended mode 1-28, wherein

a positive lens is disposed toward the object side of the $_{\rm 30}$ predetermined lens unit, and

the positive lens is disposed to be adjacent to the predetermined lens unit.

(Appended Mode 1-31)

The optical system according to one of appended modes 1-1 to 1-30, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is}$$
 (40)

where,

 R_{G1} , denotes a radius of curvature of the image-side surface of the first image-side lens, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 1-32)

The optical system according to one of appended modes 1-1 to 1-31, wherein the following conditional expression (41) is satisfied:

$$0.5 < f_{G1} / f_{G1} < 20$$
 (41)

where,

 f_{G1o} denotes the focal length of the first object-side lens, ⁵ and

 f_{G1} denotes a focal length of the first lens unit. (Appended Mode 1-33)

The optical system according to one of appended modes 1-1 to 1-32, wherein the following conditional expression ⁶⁰ (42) is satisfied:

$$0.01 < 1/v d_{G1min} - 1/v d_{G1max}$$
 (42)

where,

 vd_{G1min} denotes a smallest Abbe's number from among 65 Abbe's numbers for lenses forming the first lens unit, and

 d_{G1max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit.

The optical system according to one of appended modes 1-1 to 1-33, wherein the following conditional expression (43) is satisfied:

$$0.01 < 1/v d_{G2min} - 1/v d_{G2max}$$
 (43)

where.

 vd_{G2min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and

 vd_{G2max} denotes a largest Abbe's number from among 10 Abbe's numbers for lenses forming the second lens unit. (Appended Mode 1-35)

The optical system according to one of appended modes 1-1 to 1-34, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where

 θ_{gF} denotes a partial dispersion ratio of the positive lens, 20 and is expressed by θ_{gF} =(ng-nF)/(nF-nC), where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

(Appended Mode 1-36)

The optical system according to appended mode 1-35, 25 wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit.

(Appended Mode 1-37)

The optical system according to one of appended modes 1-35 and 1-36, wherein the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

where

 D_{p1s} denotes a distance on the optical axis from an objectside surface of the positive lens up to the stop, and

 ${\rm L}_{G1s}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the stop. (Appended Mode 1-38)

The optical system according to one of appended modes 1-1 to 1-37, wherein the optical system includes at least one diffractive optical element.

(Appended Mode 1-39)

The optical system according to one of appended modes 45 1-1 to 1-38, wherein at least one diffractive optical element is disposed at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 < D_{DLs} / D_{G1is}$$
 (48)

where,

 ${\rm D}_{DLs}$ denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 ${\rm D}_{G1is}$ denotes the distance on the optical axis from the 55 image-side surface of the first image-side lens up to the stop. (Appended Mode 1-40)

The optical system according to one of appended modes 1-1 to 1-39, wherein at least one diffractive optical element is disposed at a position which is on the image side of the stop, 60 and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

where,

 \mathbf{D}_{SDL} denotes a distance on the optical axis from the stop up to the diffractive optical element, and

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 L_{sG2} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens. (Appended Mode 1-41)

The optical system according to one of appended modes 1-1 to 1-40, wherein the optical system includes a negative lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max} \tag{50}$$

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51)

where.

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes the largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 D_{os} denotes the distance on the optical axis from the object up to the stop.

(Appended Mode 1-42)

The optical system according to one of appended modes 1-1 to 1-41, wherein the optical system includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn} \sqrt{D_{si}} < 1$$
 (54)

where.

 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 \mathbf{D}_{si} denotes a distance on the optical axis from the stop up to the image.

(Appended Mode 1-43)

An image pickup apparatus comprising:

an optical system according to one of appended modes 1-1 to 1-42; and

an image pickup element.

40 (Appended Mode 1-44)

The image pickup system comprising:

an image pickup apparatus according to appended mode 1-43;

a stage which holds an object; and

an illuminating unit which illuminates the object.

(Appended Mode 1-45)

The image pickup system according to appended mode 1-44, wherein the image pickup apparatus and the stage are integrated.

(Appended Mode 2-1)

An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,

a first lens unit which includes a plurality of lenses,

a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is 65 disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the following conditional expressions (16), (21), (23-1), and (24-1) are satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

$$0.6 \le L_L/D_{oi}$$
 (23-1)

$$0.015 < 1/vd_{min} - 1/vd_{max}$$
 (24-1)

where,

NA denotes a numerical aperture on the object side of the optical system,

 D_{max} denotes a maximum distance from among distances 15 on an optical axis of adjacent lenses in the optical system,

 ϕ_s denotes a diameter of the stop,

 L_L denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side surface of the second image-side lens,

 \mathbf{D}_{oi} denotes a distance on the optical axis from the object to the image,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

 vd_{max} denotes a largest Abbe's number from among the 25 Abbe's numbers for lenses forming the optical system. (Appended Mode 2-2)

The optical system according to appended mode 2-1, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{ob}/CRA_{img} \le 0.5$$
 (36)

where

 ${\rm D}_{ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical $_{40}$ system,

 CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes a maximum angle from among angles $_{45}$ made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 2-3)

The optical system according to one of appended modes 2-1 and 2-2, wherein the following conditional expression (25-1) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.65$$
 (25-1)

where.

 D_{os} denotes a distance on the optical axis from the object up to the stop, and

 ${\rm D}_{ot}$ denotes the distance on the optical axis from the object 60 up to the image.

(Appended Mode 2-4)

The optical system according to one of appended modes 2-1 to 2-3, the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

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where,

BF denotes a distance on an optical axis from the imageside surface of the second image-side lens up to the image, and

 \mathcal{L}_L denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 2-5)

The optical system according to one of appended modes 2-1 to 2-4, wherein

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 2-6)

The optical system according to one of appended modes 2-1 to 2-5, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is}$$
 (40)

where,

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 R_{G1i} denotes a radius of curvature of the image-side surface of the first image-side lens, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 2-7)

The optical system according to one of appended modes 2-1 to 2-6, wherein

a conjugate image of an object is formed by the first lens unit, and

a final image of the object is formed by the second lens unit, and

the following conditional expression (18) is satisfied:

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C}^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C})))/\epsilon_d < 30$$
(18)

where,

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a 50 C-line, at an image point of the first lens unit with respect to an object point on the optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the 55 image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 \mathbf{f}_{G2C} denotes a focal length for the C-line of the second lens unit, and

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 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object 5 point and a virtual image point.

(Appended Mode 2-8)

The optical system according to one of appended modes 2-1 to 2-7, wherein the following conditional expression (22) is satisfied:

$$0.01 \le D_{G2max}/\phi_s \le 2.0$$
 (22)

where,

 ${\rm D}_{G1max}$ denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens unit, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 2-9)

The optical system according to one of appended modes 2-1 to 2-8, wherein the following conditional expression (26) 20 is satisfied:

$$0.95 < \phi_{G1} / (2 \times Y/|\beta|) \tag{26}$$

where.

 φ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system, and

 β denotes an imaging magnification of the optical system. (Appended Mode 2-10)

The optical system according to one of appended modes 2-1 to 2-9, wherein the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where.

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

Y denotes the maximum image height in the overall optical system.

(Appended Mode 2-11)

The optical system according to one of appended modes 2-1 to 2-10, wherein

the second lens unit includes four lenses, and

at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and

an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, is a convex surface that is convex toward the object side. (Appended Mode 2-12)

The optical system according to one of appended modes 2-1 to 2-11, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image side, and

a distance of two lenses positioned on two side of the stop is fixed, and

the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

where.

 D_{G1G2} denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the 65 object-side surface of the second object-side lens, and

 ϕ_s denotes the diameter of the stop.

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(Appended Mode 2-13)

The optical system according to one of appended modes 2-1 to 2-12, wherein

the first lens unit includes a first image-side lens which disposed nearest to the image, and

the following conditional expression (31) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.5$$
 (31)

where,

 ${\cal L}_{G1}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 L_{G2} denotes a distance on the optical axis from an objectside surface of the second object-side lens up to the image side surface of the second image-side lens.

(Appended Mode 2-14)

The optical system according to one of appended modes 2-1 to 2-13, wherein the following conditional expression (32) is satisfied:

$$0.1 < L_{G1s} / L_{sG2} < 1.5$$
 (32)

where.

 ${\cal L}_{Gls}$ denotes a distance on the optical axis from the object-side surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens. (Appended Mode 2-15)

The optical system according to one of appended modes 2-1 to 2-14, wherein the following conditional expression (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0 \tag{33}$$

where

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 ϕ_{G1max} denotes a maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter apertures of lenses in the second lens unit. (Appended Mode 2-16)

The optical system according to one of appended modes 2-1 to 2-15, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where,

 D_{os} denotes the distance on the optical axis from the object up to the stop, and

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 2-17)

The optical system according to one of appended modes 2-1 to 2-16, wherein

the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first object-side 60 lens, and

at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

(Appended Mode 2-18)

The optical system according to one of appended modes 2-1 to 2-17, wherein the first object-side lens has a negative refractive power.

The optical system according to one of appended modes 2-1 to 2-18, wherein the following conditional expression (37-1) is satisfied:

$$f_{G1o}/f < -0.01$$
 (37-1)

 f_{G10} denotes a focal length of the first object-side lens, and f denotes a focal length of the overall optical system.

(Appended Mode 2-20)

The optical system according to one of appended modes 2-1 to 2-19, wherein an object-side surface of the first objectside lens is concave toward the object side.

(Appended Mode 2-21)

The optical system according to one of appended modes 2-1 to 2-20, wherein the following conditional expression (38-1) is satisfied:

$$R_{G1o}/WD < -0.1$$
 (38-1)

where,

 R_{G10} denotes a radius of curvature of the object-side surface of the first object-side lens, and

WD denotes a distance on the optical axis from the object up to the object-side side surface of the first object-side lens. (Appended Mode 2-22)

The optical system according to one of appended modes 2-1 to 2-21, wherein

an image-side surface of the second image-side lens is concave toward the image side, and

the following conditional expression (39) is satisfied:

$$0.1 \le R_{G2i}/BF \tag{39}$$

where.

R_{G21} denotes a radius of curvature of the image-side surface 35 of the second image-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 2-23)

The optical system according to appended mode 2-5, 40

a positive lens is disposed on the object side of the predetermined lens unit, and

the positive lens is disposed to be adjacent to the predetermined lens unit.

(Appended Mode 2-24)

The optical system according to one of appended modes 2-1 to 2-23, wherein

a shape of at least one lens surface of the second image-side lens is a shape having an inflection point.

(Appended Mode 2-25)

The optical system according to one of appended modes 2-1 to 2-24, wherein the following conditional expression (42) is satisfied:

$$0.01 < 1/V d_{G1min} - 1/V d_{G1max}$$
 (42)

 vd_{G1min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the first lens unit, and

 vd_{G1max} denotes a largest Abbe's number from among 60 Abbe's numbers for lenses forming the first lens unit. (Appended Mode 2-26)

The optical system according to one of appended modes 2-1 to 2-25, wherein the following conditional expression (43) is satisfied:

$$0.01 < 1/\nu d_{G2min} - 1/\nu d_{G2max}$$
 (43)

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where.

 vd_{G2min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and

vd_{G2max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the second lens unit. (Appended Mode 2-27)

The optical system according to one of appended modes 2-1 to 2-26, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where.

 θ_{gF} denotes a partial dispersion ratio of the positive lens, and is expressed by $\theta_{eF} = (ng-nF)/(nF-nC)$, where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

(Appended Mode 2-28)

The optical system according to appended mode 2-27, wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit.

(Appended Mode 2-29)

The optical system according to one of appended mode 2-27 and 2-28, wherein the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s} / L_{G1s} \le 1 \tag{45}$$

where,

 D_{p1s} denotes a distance on the optical axis from an objectside surface of the positive lens up to the stop, and

 L_{G1s} denotes the distance on the optical axis from an object-side surface of the first object-side lens up to the stop. (Appended Mode 2-30)

The optical system according to one of appended modes 2-1 to 2-29, wherein the first lens unit has a positive refractive power, and includes at least one diffractive optical element. (Appended Mode 2-31)

The optical system according to one of appended modes 2-1 to 2-30, wherein at least one diffractive optical element is disposed at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 < D_{DLs}/D_{G1is} \tag{48}$$

where,

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D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{Glis} denotes the distance on the optical axis from the image-side surface of the first image-side lens up to the stop. (Appended Mode 2-32)

The optical system according to one of appended modes 2-1 to 2-31, wherein at least one diffractive optical element is disposed at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

where,

 D_{SDL} denotes a distance on the optical axis from the stop up 65 to the diffractive optical element, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens.

The optical system according to one of appended modes 2-1 to 2-32, wherein the optical system includes a negative lens which satisfies the following conditional expressions (50) and (51):

$$0.01 < 1/v d_{n1} - 1/v d_{G1max}$$
 (50)

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51)

where,

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max} denotes the largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop.

(Appended Mode 2-34)

The optical system according to one of appended modes 2-1 to 2-33, wherein the optical system includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3} / D_{si} < 1$$
 (54)

where.

 D_{sn3} denotes a distance on the optical axis from the stop up ²⁵ to an image-side surface of the negative lens, and

 D_{st} denotes a distance on the optical axis from the stop up to the image.

(Appended Mode 2-35)

The optical system according to one of appended modes 2-1 to 2-34, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_I/D_{ci} + 0.07 \times WD/BF$$
 (56)

where.

 ${\rm L_{\it L}}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 D_{st} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 2-36)

The optical system according to one of appended modes 2-1 to 2-35, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.8 (57)

where,

 D_{os} denotes the distance on the optical axis from the object up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and 60

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 2-37)

An image pickup apparatus comprising:

an optical system according to one of appended modes 2-1 $\,$ 65 to 2-36; and

an image pickup element.

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(Appended Mode 2-38)

An image pickup system comprising:

an image pickup apparatus according to appended mode 2-37:

5 a stage which holds an object; and

an illuminating unit which illuminates the object.

(Appended Mode 2-39)

The image pickup system according to appended mode 2-38, wherein the image pickup apparatus and the stage are integrated.

(Appended Mode 3-1)

An optical system comprising in order from an object side, a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (9-1), and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_1/\Sigma d < 0.2$$
 (9-1)

$$-20 < \Delta f_{cd} < d < 20 \tag{13}$$

where,

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the 30 optical system,

β denotes a projection magnification of the optical system,

d₁ denotes a distance on an optical axis from a surface positioned nearest to the image side of the lens unit Gf up to a surface positioned nearest to the object side of the lens unit 35 Gr,

Σd denotes a sum total of lens thickness on the optical axis of an overall optical system,

€d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side.

45 (Appended Mode 3-2)

The optical system according to appended mode 3-1, wherein the following conditional expression (6) is satisfied:

$$0.5 < f_{OB}/f_{TL} < 2$$
 (6)

where,

50

 ${\bf f}_{OB}$ denotes a focal length of the lens unit Gf, and ${\bf f}_{TL}$ denotes a focal length of the lens unit Gr.

(Appended Mode 3-3)

The optical system according to one of appended modes 3-1 and 3-2, wherein the following conditional expression (14) is satisfied:

$$0.7 < d_{SHOB}/d_{SHTL} < 1.3$$
 (14)

where.

 d_{SHOB} denotes a distance on the optical axis from a front principal point of the lens unit Gf up to the stop, and

 d_{SHTL} denotes a distance on the optical axis from the stop up to a rear principal point of the lens unit Gr. (Appended Mode 3-4)

The optical system according to one of appended modes 3-1 to 3-3, wherein a positive lens Lf1 is disposed nearest to an image in the lens unit Gf.

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(Appended Mode 3-5)

The optical system according to one of appended modes 3-1 to 3-4, wherein the lens unit Gf includes a lens Lfe which is disposed nearest to the object, and at least one lens surface of the lens Lfe has a shape which has an inflection point. (Appended Mode 3-6)

The optical system according to one of appended modes 3-1 to 3-5, wherein the lens unit Gr includes a lens Lre which is disposed nearest to the image, and at least one lens surface of the lens Lre has a shape which has an inflection point. (Appended Mode 3-7)

The optical system according to one of appended modes 3-1 to 3-6, wherein the following conditional expressions (7-1) and (8-1) are satisfied:

$$40\% \le MTF_{OB}$$
 (7-1)

MTF_{OR} denotes an MTF on an axis of the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

 MTF_{TL} denotes an MTF on an axis of the lens unit Gr, and is an MTF with respect to a spatial frequency of fc'/4, where

fc denotes a cut-off frequency with respect to the numerical 25 aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both MTF_{OB} and MTF_{TL} are MTFs at positions at which, light is focused when parallel light of an e-line is made to be incident 30 from a direction of the stop side, respectively.

(Appended Mode 3-8)

The optical system according to one of appended modes 3-1 to 3-7, wherein a positive lens Lr1 is disposed nearest to the object in the lens unit Gr.

(Appended Mode 3-9)

The optical system according to one of appended modes 3-1 to 3-8, wherein a negative lens Lf2 is disposed on the object side of the positive lens Lf1 such that, the negative lens Lf2 is adjacent to the positive lens Lf1.

(Appended Mode 3-10)

The optical system according to one of appended modes 3-1 to 3-9, wherein a negative lens Lr2 is disposed on the image side of the positive lens Lr1 such that, the negative lens Lr2 is adjacent to the positive lens Lr1.

(Appended Mode 3-11)

The optical system according to one of appended modes 3-1 to 3-10, wherein an object-side surface of the negative lens Lf2 is concave toward the object side.

(Appended Mode 3-12)

The optical system according to one of appended modes 3-1 to 3-11, wherein an image-side surface of the negative lens Lr2 is concave toward the image side.

(Appended Mode 3-13)

The optical system according to one of appended modes 55 3-1 to 3-12, wherein the lens Lfe has a negative refractive

(Appended Mode 3-14)

The optical system according to one of appended modes 3-1 to 3-13, wherein the lens Lre has a negative refractive 60

(Appended Mode 3-15)

The optical system according to one of appended modes 3-1 to 3-14, wherein

the optical system includes at least one pair of lenses which 65 satisfies the following conditional expressions (1), (2), and (3), and

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one lens in the pair of lenses is included in the lens unit Gf,

the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OB}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OBr} / r_{TLf} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OBr} denotes a paraxial radius of curvature of an image-side 15 surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 r_{TLr} denotes a paraxial radius of curvature of an image-side surface of the other lens in the pair of lenses,

 d_{OB} denotes a thickness on the optical axis of the one lens in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

(Appended Mode 3-16)

The optical system according to one of appended modes 3-1 to 3-15, wherein the following conditional expression (12-1) is satisfied:

$$-10^{\circ} < \theta_o < 30^{\circ}$$
 (12-1)

θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object side.

(Appended Mode 3-17)

An optical instrument comprising:

an optical system according to one of appended modes 3-1 to 3-16; and

an image pickup element.

(Appended Mode 4-1)

An optical system comprising in order from an object side, a lens unit Gf having a positive refractive power,

a stop, and

a lens unit Gr having a positive refractive power, and the following conditional expressions (4-1), (5), (10-1), 45 and (13) are satisfied:

$$-2 < \beta < -0.5$$
 (5)

$$0 < d_2/\Sigma d < 2 \tag{10-1}$$

$$-20 < \Delta f_{cd} / \epsilon d < 20 \tag{13}$$

where.

NA denotes a numerical aperture on the object side of the optical system,

NA' denotes a numerical aperture on an image side of the optical system,

 β denotes a projection magnification of the optical system, d₂ denotes a distance on an optical axis from a front principal point of the lens unit Gf up to a rear principal point of the lens unit Gr.

 Σ d denotes a sum total of lens thickness on the optical axis of an overall optical system,

€d denotes an Airy disc radius for a d-line which is determined by the numerical aperture on the image side of the optical system, and

 Δf_{cd} denotes a difference in a focal position on a C-line and a focal position on the d-line, which is a difference in positions at which light is focused when parallel light is made to be incident on the lens unit Gr from the stop side. (Appended Mode 4-2)

The optical system according to appended mode 4-1, wherein the following conditional expression (6) is satisfied:

$$0.5 < f_{OB} / f_{TL} < 2$$
 (6)

where.

 f_{OB} denotes a focal length of the lens unit Gf, and f_{TL} denotes a focal length of the lens unit Gr. (Appended Mode 4-3)

The optical system according to one of appended modes 4-1 and 4-2, wherein the following conditional expression ¹⁵ (14) is satisfied:

$$0.7 < d_{SHOB}/d_{SHTL} < 1.3$$
 (14)

where.

 ${
m d}_{SHOB}$ denotes a distance on the optical axis from the front principal point of the lens unit Gf up to the stop, and

d_{SHTL} denotes a distance on the optical axis from the stop up to the rear principal point of the lens unit Gr. (Appended Mode 4-4)

The optical system according to one of appended modes 4-1 to 4-3, wherein a positive lens Lf1 is disposed nearest to an image in the lens unit Gf.

(Appended Modes 4-5)

The optical system according to one of appended modes 4-1 to 4-4, wherein the lens unit Gf includes a lens Lfe which is disposed nearest to the object, and at least one lens surface of the lens Lfe has a shape which has an inflection point. (Appended Mode 4-6)

The optical system according to one of appended modes 4-1 to 4-5, wherein the lens unit Gr includes a lens Lre which is disposed nearest to the image, and at least one lens surface of the lens Lre has a shape which has an inflection point. (Appended Mode 4-7)

The optical system according to one of appended modes 4-1 to 4-6, wherein the following conditional expressions (7-1) and (8-1) are satisfied:

$$40\% \leq MTF_{OB} \tag{7-1}$$

where,

 MTF_{OB} denotes an MTF on an axis of the lens unit Gf, and is an MTF with respect to a spatial frequency of fc/4,

MTF_{TL} denotes an MTF on an axis of the lens unit Gr, and 50 is an MTF with respect to a spatial frequency of fc!/4, where fc denotes a cut-off frequency with respect to the numerical aperture on the object side of the optical system, and

fc' denotes a cut-off frequency with respect to the numerical aperture on the image side of the optical system, and both 55 MTF $_{OB}$ and MTF $_{TL}$ are MTFs at positions at which light is focused when parallel light of an e-line is made to be incident from a direction of the stop side, respectively.

(Appended Mode 4-8)

The optical system according to one of appended modes 60 4-1 to 4-7, wherein a positive lens Lr1 is disposed nearest to the object in the lens unit Gr.

(Appended Mode 4-9)

The optical system according to one of appended modes 4-1 to 4-8, wherein a negative lens Lf2 is disposed on the object side of the positive lens Lf1 such that, the negative lens Lf2 is adjacent to the positive lens Lf1.

(Appended Mode 4-10)

The optical system according to one of appended modes 4-1 to 4-9, wherein a negative lens Lr2 is disposed on the image side of the positive lens Lr1 such that, the negative lens Lr2 is adjacent to the positive lens Lr1.

(Appended Mode 4-11)

The optical system according to one of appended modes 4-1 to 4-10, wherein an object-side surface of the negative lens Lf2 is concave toward the object side.

10 (Appended Mode 4-12)

The optical system according to one of appended modes 4-1 to 4-11, wherein an image-side surface of the negative lens Lr2 is concave toward image side. (Appended Mode 4-13)

The optical system according to one of appended modes 4-1 to 4-12, wherein the lens Lfe has a negative refractive power.

(Appended Mode 4-14)

The optical system according to one of appended modes 20 4-1 to 4-13, wherein the lens Lre has a negative refractive power.

(Appended Mode 4-15)

The optical system according to one of appended modes 4-1 to 4-14, wherein

the optical system includes at least one pair of lenses which satisfies the following conditional expressions (1), (2), and (3), and

one lens in the pair of lenses is included in the lens unit Gf, and

the other lens in the pair of lenses is included in the lens unit Gr:

$$-1.1 < r_{OB}/r_{TLr} < -0.9$$
 (1)

$$-1.1 < r_{OBr} / r_{TLf} < -0.9$$
 (2)

$$-0.1 < (d_{OB} - d_{TL})/(d_{OB} + d_{TL}) < 0.1$$
 (3)

where,

 r_{OBf} denotes a paraxial radius of curvature of an object-side surface of the one lens in the pair of lenses,

 r_{OBr} denotes a paraxial radius of curvature of an image-side surface of the one lens in the pair of lenses,

 r_{TLf} denotes a paraxial radius of curvature of an object-side surface of the other lens in the pair of lenses,

 r_{TLr} denotes a paraxial radius of curvature of an image-side surface of the other lens in the pair of lenses,

 \mathbf{d}_{OB} denotes a thickness on the optical axis of the one lens in the pair of lenses, and

 d_{TL} denotes a thickness on the optical axis of the other lens in the pair of lenses.

(Appended Mode 4-16)

The optical system according to one of appended modes 4-1 to 4-15, wherein the following conditional expression (12-1) is satisfied:

$$-10^{\circ} < \theta_{o} < 30^{\circ}$$
 (12-1)

where,

 θ_o denotes an angle made by a normal of a plane perpendicular to the optical axis with a principal ray on the object side.

(Appended Mode 4-17)

An optical instrument comprising:

an optical system according to one of appended modes 4-1 to 4-16; and

an image pickup element.

(Appended Mode 5-1)

An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged

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in rows two-dimensionally, which converts a light intensity to an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, and for which, a pitch of pixels is not more than 5.0 μm , comprising in order from an object side,

a first lens unit which includes a plurality of lenses, a stop, and

a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first 10 lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to the object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

a conjugate image of the object is formed by the first lens unit, and

a final image of the object is formed by the second lens unit, and

the following conditional expressions (16), (18), and (25) 20 5-1 to 5-3, wherein are satisfied: the first lens unit

$$0.0 < NA$$
 (16)

$$-30 < (\Delta D_{G2dC} + (\Delta D_{G1dC} \times \beta_{G2C})^2 / (1 + \beta_{G2C} \times \Delta D_{G1dC} / f_{G2C})) / \epsilon_d < 30$$
 (18)

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

NA denotes a numerical aperture on the object side of the $\,^{30}$ optical system,

 ΔD_{G1dC} denotes a distance from a position of an image point P_{G1} on a d-line up to a position of an image point on a C-line, at an image point of the first lens unit with respect to an object point on an optical axis,

 ΔD_{G2dC} denotes a distance from a position of an image point on the d-line up to a position of an image point on the C-line, at an image point of the second lens unit, when the image point P_{G1} is let to be an object point of the second lens unit, where

 ΔD_{G1dC} and ΔD_{G2dC} are let to be positive in a case in which, the position of the image point on the C-line is on the image side of the position of the image point on the d-line, ΔD_{G1dC} and ΔD_{G2dC} are let to be negative in a case in which, the position of the image point on the C-line is on the object side of the position of the image point on the d-line,

 β_{G2C} denotes an imaging magnification for the C-line of the second lens unit when the image point P_{G1} is let to be the object point of the second lens unit,

 ${\bf f}_{G2C}$ denotes a focal length for the C-line of the second lens 50 unit,

 ϵ_d denotes an Airy disc radius for the d-line, which is determined by the numerical aperture on the image side of the optical system,

 D_{os} denotes a distance on the optical axis from the object up 55 to the stop, and

 D_{oi} denotes a distance on the optical axis from the object up to the image, and

the object point and the image point are points on the optical axis, and also include cases of being a virtual object 60 point and a virtual image point.

(Appended Mode 5-2)

The optical system according to appended mode 5-1, wherein the following conditional expression (24) is satisfied:

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where,

 vd_{min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes a largest Abbe's number from among 5 Abbe's numbers for lenses forming the optical system. (Appended Mode 5-3)

The optical system according to one of appended modes 5-1 and 5-2, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_I/D_{oi} \tag{23}$$

where,

 ${\rm L}_{L}$ denotes a distance on the optical axis from an objectside surface of the first object-side lens up to an image-side surface of the second image-side lens, and

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5-4)

The optical system according to one of appended modes 5-1 to 5-3, wherein

the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where,

WD denotes a distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes a distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-5)

The optical system according to one of appended modes 5-1 to 5-4, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

where

 ${\rm L}_L$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 \mathbf{D}_{oi} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-6)

The optical system according to one of appended modes 5-1 to 5-5, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31-1) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.4$$
 (31-1)

where,

 ${\cal L}_{G1}$ denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\cal L}_{G2}$ denotes a distance on the optical axis from an objectside surface of the second object-side lens up to the image side surface of the second image-side lens.

(Appended Mode 5-7)

The optical system according to one of appended modes 5-1 to 5-6, wherein

the first lens unit includes the first image-side lens which is disposed nearest to the image, and

(34)

the following conditional expression (34) is satisfied:

 $0.01 < 1/v d_{min} - 1/v d_{max}$ (24) $0.5 < D_{os}/L_{G1} < 4.0$

where,

 D_{os} denotes the distance on the optical axis from the object up to the stop, and

 ${\rm L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the 5 image-side surface of the first image-side lens.

(Appended Mode 5-8)

The optical system according to one of appended modes 5-1 to 5-7, wherein

the first lens unit includes the first image-side lens which is 10 disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
=0.39×WD/BF<1.8 (57)

where,

 D_{os} denotes the distance on the optical axis from the object up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-9)

The optical system according to one of appended modes 5-1 to 5-8, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27) 30

where.

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

 ${\cal L}_L$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 5-10)

The optical system according to one of appended modes 5-1 to 5-9, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} < 0.5 \tag{36}$$

where,

 ${\rm D}_{ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in an overall optical system,

 CRA_{obj} denotes a maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes a maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of 60 counterclockwise rotation is let to be a positive angle. (Appended Mode 5-11)

The optical system according to one of appended modes 5-1 to 5-10, wherein

the first lens unit includes a negative lens, and a positive 65 lens which is disposed on the object side of the negative lens, and

the following conditional expression (20-1) is satisfied:

$$1.0 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obi})/\phi_s \le 5.0$$
 (20-1)

where,

WD denotes the distance on an optical axis from the object up to the object-side surface of the first object-side lens,

NA denotes the numerical aperture on the object side of the optical system,

Yobj denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

(Appended Mode 5-12)

The optical system according to one of appended modes 5-1 to 5-11, wherein the following conditional expression 15 (21) is satisfied:

$$0.01 < D_{max} / \phi_s < 3.0$$
 (21)

where,

 D_{max} denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5-13)

The optical system according to one of appended modes 5-1 to 5-12, wherein

the first lens unit includes the first object-side lens, and a lens which is disposed to be adjacent to the first object-side lens, and

at least one of the first object-side lens and the lens disposed to be adjacent to the first object-side lens has a positive refractive power.

(Appended Mode 5-14)

The optical system according to one of appended modes 55 5-1 to 5-13, wherein

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 5-15)

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The optical system according to appended mode 5-14, wherein

a positive lens is disposed on the object side of the predetermined lens unit, and

the positive lens is disposed to be adjacent to the predetermined lens unit.

(Appended Mode 5-16)

The optical system according to one of appended modes 5-1 to 5-15, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

the following conditional expression (40) is satisfied:

$$0.2 < R_{G1i}/D_{G1is} \tag{40}$$

where,

 R_{G1i} denotes a radius of curvature of the image-side surface of the first image-side lens, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop.

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The optical system according to one of appended modes 5-1 to 5-16, wherein the optical system includes at least one positive lens which satisfies the following conditional expression (44):

$$0.59 < \theta_{gF} < 0.8$$
 (44)

where,

 θ_{gF} denotes a partial dispersion ratio of the positive lens, and is expressed by θ_{gF} =(ng-nF)/(nF-nC), where

nC, nF, and ng denote refractive indices with respect to a C-line, an F-line, and a g-line respectively.

(Appended Mode 5-18)

The optical system according to appended mode 5-17, wherein the positive lens which satisfies conditional expression (44) is included in the first lens unit.

(Appended Mode 5-19)

The optical system according to one of appended modes 5-17 and 5-18, wherein the positive lens which satisfies conditional expression (44), satisfies the following conditional expression (45):

$$0.3 < D_{p1s}/L_{G1s} \le 1$$
 (45)

where

 D_{p1s} denotes a distance on the optical axis from an objectside surface of the positive lens up to the stop, and

 L_{G1s} denotes a distance on the optical axis from an objectside surface of the first object-side lens up to the stop. (Appended Mode 5-20)

The optical system according to one of appended modes 5-1 to 5-19, wherein the following conditional expression (28) is satisfied:

$$0 < BF/Y < 7.0$$
 (28)

where,

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

Y denotes the maximum image height in the overall optical system.

(Appended Mode 5-21)

The optical system according to one of appended modes 5-1 to 5-20, wherein the following conditional expression (22) is satisfied:

$$0.01 \le D_{G1max}/\phi_s < 2.0$$
 (22) 45

where,

 ${\rm D}_{G1max}$ denotes a maximum distance from among distances on the optical axis of the adjacent lenses in the first lens unit, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5-22)

The optical system according to one of appended modes 5-1 to 5-21, wherein the optical system satisfies the following conditional expression (26) is satisfied:

$$0.95 < \phi_{G1o}/(2 \times Y/|\beta|) \tag{26}$$

where,

 ϕ_{G1o} denotes an effective diameter of the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical $_{60}$ system, and

 β denotes an imaging magnification of the optical system. (Appended Mode 5-23)

The optical system according to one of appended modes 5-1 to 5-22, wherein the following conditional expression (29) is satisfied:

$$-0.2 < \phi_{G1o}/R_{G1o} < 3.0$$
 (29)

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where.

 ϕ_{G1o} denotes the effective diameter of the object-side surface of the first object-side lens, and

 R_{G1o} denotes a radius of curvature of the object-side surface of the first object-side lens.

(Appended Mode 5-24)

The optical system according to one of appended modes 5-1 to 5-23, wherein

the second lens unit includes four lenses, and

at least one of the four lenses in the second lens unit is a negative lens, and at least one of the four lenses in the second lens unit is a positive lens, and

an object-side surface of the positive lens from among the positive lenses, which is positioned nearest to the object side, is a convex surface that is convex toward the object side. (Appended Mode 5-25)

The optical system according to one of appended modes 5-1 to 5-24, wherein

the first lens unit includes a first image-side lens which is 20 disposed nearest to the image side, and

a distance of two lenses positioned on two side of the stop is fixed, and

the following conditional expression (30) is satisfied:

$$D_{G1G2}/\phi_s < 2.0$$
 (30)

where,

 D_{G1G2} denotes a distance on the optical axis from the image-side surface of the first image-side lens up to the object-side surface of the second object-side lens, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5-26)

The optical system according to one of appended modes 5-1 to 5-25, wherein the following conditional expression (32) is satisfied:

$$0.1 < L_{G1s} / L_{sG2} < 1.5$$
 (32)

where

 ${\cal L}_{G1s}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the stop, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image side surface of the second image-side lens. (Appended Mode 5-27)

The optical system according to one of appended modes 5-1 to 5-26, wherein the following conditional expression (33) is satisfied:

$$0.8 \le \phi_{G1max}/\phi_{G2max} \le 5.0 \tag{33}$$

where,

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 ϕ_{G1max} denotes the maximum effective diameter from among effective diameter of lenses in the first lens unit, and

 ϕ_{G2max} denotes a maximum effective diameter from among effective diameter of lenses in the second lens unit.

55 (Appended Mode 5-28)

The optical system according to one of appended modes 5-1 to 5-27, wherein the first object-side lens has a positive refractive power.

(Appended Mode 5-29)

The optical system according to one of appended modes 5-1 to 5-28, wherein the following conditional expression (37) is satisfied:

$$0.05 < f_{G1} / f$$
 (37)

where,

 f_{G1o} denotes a focal length of the first object-side lens, and f denotes a focal length of the overall optical system.

(Appended Mode 5-30)

The optical system according to one of appended modes 5-1 to 5-29, wherein an object-side surface of the first object-side lens is convex toward the object.

(Appended Mode 5-31)

The optical system according to one of appended modes 5-1 to 5-30, wherein the optical system satisfies the following conditional expression (38) is satisfied:

$$0.02 < R_{GL} / WD$$
 (38)

where,

 R_{G1o} denotes the radius of curvature of the object-side surface of the first object-side lens, and

WD denotes the distance on the optical axis from the object up to the object-side side surface of the first object-side lens. 15 (Appended Mode 5-32)

The optical system according to one of appended modes 5-1 to 5-31, wherein

an image-side surface of the second image-side lens is concave toward the image side, and

the following conditional expression (39) is satisfied:

$$0.1 \le R_{G2i}/BF$$
 (39)

where.

 R_{G2i} denotes a radius of curvature of the image-side surface 25 of the second image-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-33)

The optical system according to one of appended modes 30 5-1 to 5-32, wherein the following conditional expression (41) is satisfied:

$$0.5 < f_{G1} / f_{G1} < 20$$
 (41)

where,

 \mathbf{f}_{G1o} denotes the focal length of the first object-side lens, and

 f_{G1} denotes a focal length of the first lens unit. (Appended Mode 5-34)

The optical system according to one of appended modes 40 5-1 to 5-33, wherein the optical system satisfies the following conditional expression (42) is satisfied:

$$0.01 \le 1/v d_{G1min} - 1/v d_{G1max}$$
 (42)

where.

 vd_{G1min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the first lens unit, and

 vd_{G1max} denotes the largest Abbe's number from among Abbe's numbers for lenses forming the first lens unit. (Appended Mode 5-35)

The optical system according to one of appended modes 5-1 to 5-34, wherein the following conditional expression (43) is satisfied:

$$0.01 < 1/\nu d_{G2min} - 1/\nu d_{G2max}$$
 (43)

where

 vd_{G2min} denotes a smallest Abbe's number from among Abbe's numbers for lenses forming the second lens unit, and vd_{G2max} denotes a largest Abbe's number from among Abbe's numbers for lenses forming the second lens unit. (Appended Mode 5-36)

The optical system according to one of appended modes 5-1 to 5-35, wherein the first lens unit has a positive refractive power, and includes at least one diffractive optical element. (Appended Mode 5-37)

The optical system according to one of appended modes 5-1 to 5-36, wherein at least one diffractive optical element is

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disposed at a position which is on the object side of the stop, and at the position which satisfies the following conditional expression (48):

$$0.1 < D_{DLs}/D_{G1is}$$
 (48)

where.

 D_{DLs} denotes a distance on the optical axis from the diffractive optical element up to the stop, and

 D_{G1is} denotes a distance on the optical axis from the imageside surface of the first image-side lens up to the stop. (Appended Mode 5-38)

The optical system according to one of appended modes 5-1 to 5-37, wherein at least one diffractive optical element is disposed at a position which is on the image side of the stop, and at the position which satisfies the following conditional expression (49):

$$0.2 < D_{sDL}/L_{sG2} < 0.9$$
 (49)

where.

 ${\rm D}_{sDL}$ denotes a distance on the optical axis from the stop up to the diffractive optical element, and

 L_{sG2} denotes a distance on the optical axis from the stop up to the image-side surface of the second image-side lens. (Appended Mode 5-39)

The optical system according to one of appended modes 5-1 to 5-38, wherein the optical system includes a negative lens which satisfies the following conditional expressions (50) and (51):

$$0.01 \le 1/V d_{n1} - 1/V d_{G1max}$$
 (50)

$$0 < D_{n1s}/D_{os} < 0.3$$
 (51)

where.

 vd_{n1} denotes Abbe's number for the negative lens,

 vd_{G1max}^{n1} denotes the largest Abbe's number from among the Abbe's numbers for lenses forming the first lens unit,

 D_{n1s} denotes a distance on the optical axis from an objectside surface of the negative lens up to the stop, and

 D_{os} denotes the distance on the optical axis from the object up to the stop.

(Appended Mode 5-40)

The optical system according to one of appended modes 5-1 to 5-39, wherein the optical system includes a negative lens at a position which satisfies the following conditional expression (54):

$$0.6 < D_{sn3}/D_{si} < 1$$
 (54)

where

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 D_{sn3} denotes a distance on the optical axis from the stop up to an image-side surface of the negative lens, and

 \mathbf{D}_{si} denotes a distance on the optical axis from the stop up to the image.

(Appended Mode 5-41)

The optical system according to one of appended modes

5-1 to 5-40, wherein the following conditional expression

(43) 55 (56) is satisfied:

$$0.78 < L_I/D_{oi} + 0.07 \times WD/BF$$
 (56)

where.

 ${\rm L}_L$ denotes the distance on the optical axis from the object-60 side surface of the first object-side lens up to the image-side surface of the second image-side lens,

 \mathbf{D}_{ot} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image.

The optical system according to one of appended modes 5-1 to 5-41, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1} = 0.39 \times WD/BF < 1.8$$
 (57)

where.

 D_{os} denotes the distance on the optical axis from the object 10 up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object 15 up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5-43)

An image pickup apparatus comprising:

an optical system according to one of appended modes 5-1 to 5-42; and

an image pickup element.

(Appended Mode 5-44)

An image pickup system comprising:

an image pickup apparatus according to appended mode 5-43:

a stage which holds an object; and

an illuminating unit which illuminates the object.

(Appended Mode 5-45)

The image pickup system according to appended mode 5-44, wherein the image pickup apparatus and the stage are integrated.

(Appended Mode 5'-2)

The optical system according to appended mode 5-1, 35 wherein the following conditional expression (24) is satisfied:

$$0.01 < 1/v d_{min} - 1/v d_{max}$$
 (24)

vd_{min} denotes the smallest Abbe's number from among Abbe's numbers for lenses forming the optical system, and

vd_{max} denotes the largest Abbe's number from among Abbe's numbers for lenses forming the optical system. (Appended Mode 5'-3)

The optical system according to one of appended modes 5-1 and 5'-2, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_U / D_{oi}$$
 (23) 50

 L_{r} denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens, and

up to the image.

(Appended Mode 5'-4)

The optical system according to one of appended modes 5-1, 5'-2, and 5'-3, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where.

 D_{max} denotes the maximum distance from among distances on the optical axis of adjacent lenses in the optical system, 65

 ϕ_s denotes the diameter of the stop.

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(Appended Mode 5'-5)

The optical system according to one of appended mode 5-1, and appended modes 5'-2 to 5'-4, wherein the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

 D_{os} denotes the distance on the optical axis from the object up to the stop, and

 D_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5'-6)

The optical system according to one of appended mode 5-1 and appended modes from 5'-2 to 5'-5, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image,

 L_L denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 5'-7)

The optical system according to one of appended mode 5-1, and appended modes 5'-2 to 5'-6, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5 \tag{36}$$

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 D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes the maximum image height in the overall optical system,

CRA_{obi} denotes the maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 CRA_{img} denotes the maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 5'-8)

The optical system according to one of appended mode 5-1 and appended modes 5'-2 to 5'-7, wherein

the second lens unit includes a predetermined lens unit nearest to the image, and

the predetermined lens unit has a negative refractive power D_{oi} denotes the distance on the optical axis from the object 55 as a whole, and consists a single lens having a negative refractive power or two single lenses, and

the two single lenses consist in order from the object side, a lens having a negative refractive power, and a lens having one of a positive refractive power and a negative refractive power.

(Appended Mode 5'-9)

The optical system according to one of appended mode 5-1 and appended modes 5'-2 to 5'-8, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

an image-side surface of the first image-side lens is concave toward the image side, and

$$0.2 < R_{G1i}/D_{G1is} \tag{40}$$

where,

 R_{G1i} denotes the radius of curvature of the image-side $_{5}$ surface of the first image-side lens, and

 D_{G1is} denotes the distance on the optical axis from the image-side surface of the first image-side lens up to the stop. (Appended Mode 5"-2)

The optical system according to appended mode 5-1, $_{10}$ wherein

the first lens unit has a positive refractive power, and the following conditional expression (19) is satisfied:

$$1.0 < WD/BF \tag{19}$$

where.

WD denotes the distance on an optical axis from the object up to an object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5"-3)

The optical system according to one of appended modes 5-1 and 5"-2, wherein

the first lens unit includes a negative lens, and a positive lens which is disposed on the object side of the negative lens, and

the following conditional expression (20-1) is satisfied:

$$1.0 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj})/\phi_s \le 5.0$$
 (20-1)

where.

WD denotes the distance on an optical axis from the object 30 up to the object-side surface of the first object-side lens,

NA denotes the numerical aperture on the object side of the optical system,

Yobi denotes the maximum object height, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5"-4)

The optical system according to one of appended modes 5-1, 5"-2, and 5"-3, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where.

 ${\rm L}_{\rm L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens, and

 D_{oi} denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5"-5)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-4, wherein the following 50 conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and

 ${\rm L}_{L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens.

(Appended Mode 5"-6)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-5, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5$$

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where

 ${\rm D}_{ENP}$ denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,

Y denotes a maximum image height in the overall optical system,

 CRA_{obj} denotes the maximum angle from among angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and

 ${\rm CRA}_{img}$ denotes the maximum angle from among angles made by a principal ray that is incident on an image plane, with the optical axis, and

an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle. (Appended Mode 5"-7)

The optical system according to one of appended modes 5-1, and appended modes 5"-2 to 5"-6, wherein the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where.

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 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop, and

 ${\rm D}_{oi}$ denotes the distance on the optical axis from the object up to the image.

(Appended Mode 5"-8)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-7, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31-1) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.4$$
 (31-1)

where,

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 ${\cal L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to an image-side surface of the first image-side lens, and

 ${\rm L}_{G2}$ denotes the distance on the optical axis from an object-side surface of the second object-side lens up to the image side surface of the second image-side lens. (Appended Mode 5"-9)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-8, wherein

the first lens unit includes the first image-side lens which is disposed nearest to the image, and

the following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where

 \mathbf{D}_{os} denotes the distance on the optical axis from the object up to the stop, and

 ${\cal L}_{G1}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

(Appended Mode 5"-10)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-9, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

where,

(36)

 D_{max} denotes a maximum distance from among distances 65 on the optical axis of adjacent lenses in the optical system, and

 ϕ_s denotes the diameter of the stop.

(Appended Mode 5"-11)

The optical system according to one of appended mode 5-1, and appended modes 5"-2 to 5"-10, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_L/D_{oi} + 0.07 \times WD/BF$$
 (56)

L_z denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the image-side surface of the second image-side lens,

D_{ai} denotes the distance on the optical axis from the object up to the image,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image. (Appended Mode 5"-12)

The optical system according one of appended modes 5-1, and appended modes 5"-2 to 5"-11, wherein

the first lens unit includes a first image-side lens which is $\ ^{20}$ disposed nearest to the image, and

the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
-0.39×*WD/BF*<1.8 (57)

D_{os} denotes the distance on the optical axis from the object up to the stop,

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the 30 image-side surface of the first image-side lens,

WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and

BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image.

As described heretofore, the present invention is suitable for an optical system in which, the numerical aperture on the image side is large, and various aberrations are corrected favorably, and an optical instrument in which such optical system is used. Moreover, the present invention is suitable for 40 an optical system in which, an aberration is corrected favorably, and while having a high resolution because of the favorable correction of aberration, the overall length of the optical system is short, and for an image pickup apparatus and an image pickup system in which such optical system is used.

What is claimed is:

- 1. An optical system which forms an optical image on an image pickup element including a plurality of pixels arranged in rows two-dimensionally, which converts a light intensity to 50 an electric signal, and a plurality of color filters disposed on the plurality of pixels respectively, comprising in order from an object side,
 - a first lens unit having a positive refractive power, which includes a plurality of lenses,
 - a stop, and
 - a second lens unit which includes a plurality of lenses, wherein

lens units which form the optical system include the first lens unit and the second lens unit, and

the first lens unit includes a first object-side lens which is disposed nearest to an object, and

the second lens unit includes a second image-side lens which is disposed nearest to an image, and

the first lens unit includes a negative lens, and a positive 65 lens which is disposed on the object side of the negative lens, and

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the following conditional expressions (15), (16), (19), and (20) are satisfied:

$$\beta \leq -1.1 \tag{15}$$

$$0.08 < NA$$
 (16)

$$1.0 < WD/BF \tag{19}$$

$$0.5 \le 2 \times (WD \times \tan(\sin^{-1} NA) + Y_{obj}) / \phi_s \le 4.0$$
 (20)

 β denotes an imaging magnification of the optical system, NA denotes a numerical aperture on the object side of the optical system,

WD denotes a distance on an optical axis from the object up to an object-side surface of the first object-side lens,

BF denotes a distance on the optical axis from an imageside surface of the second image-side lens up to the

Yobj denotes a maximum object height, and

 ϕ_s denotes a diameter of the stop.

2. The optical system according to claim 1, wherein

the first lens unit includes a first image-side lens which is disposed nearest to the image, and

the following conditional expression (31) is satisfied:

$$0.1 < L_{G1}/L_{G2} < 1.5$$
 (31)

where,

 L_{G1} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to an imageside surface of the first image-side lens, and

 L_{G2} denotes a distance on the optical axis from an objectside surface of the second object-side lens up to an image side surface of the second image-side lens.

3. The optical system according to claim 2, wherein the following conditional expression (25) is satisfied:

$$0.15 < D_{os}/D_{oi} < 0.8$$
 (25)

where,

 D_{as} denotes a distance on the optical axis from the object up to the stop, and

 D_{oi} denotes a distance on the optical axis from the object up to the image.

4. The optical system according to claim 3, wherein the following conditional expression (23) is satisfied:

$$0.4 < L_L/D_{oi}$$
 (23)

where,

 L_{I} denotes a distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens, and

 D_{oi} denotes the distance on the optical axis from the object up to the image.

5. The optical system according to claim 4, wherein the ⁵⁵ following conditional expression (34) is satisfied:

$$0.5 < D_{os}/L_{G1} < 4.0$$
 (34)

where,

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 D_{os} denotes the distance on the optical axis from the object up to the stop, and

 L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens.

6. The optical system according to claim 5, wherein the following conditional expression (21) is satisfied:

$$0.01 < D_{max}/\phi_s < 3.0$$
 (21)

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where.

- D_{max} denotes a maximum distance from among distances on the optical axis of adjacent lenses in the optical system, and
- ϕ_s denotes the diameter of the stop.
- 7. The optical system according to claim 6, wherein the following conditional expression (56) is satisfied:

$$0.78 < L_I/D_{ci} + 0.07 \times WD/BF$$
 (56)

where.

- ${
 m L}_{L}$ denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the second image-side lens,
- D_{oi} denotes the distance on the optical axis from the object up to the image,
- WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and
- BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image.
- **8.** The optical system according to claim **7**, wherein the following conditional expression (57) is satisfied:

$$D_{os}/L_{G1}$$
=0.39×*WD/BF*<1.8 (57)

where

- ${\rm D}_{os}$ denotes the distance on the optical axis from the object up to the stop,
- L_{G1} denotes the distance on the optical axis from the object-side surface of the first object-side lens up to the image-side surface of the first image-side lens,
- WD denotes the distance on the optical axis from the object up to the object-side surface of the first object-side lens, and
- BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image.

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9. The optical system according to claim **8**, wherein the following conditional expression (27) is satisfied:

$$0 < BF/L_L < 0.4$$
 (27)

where,

- BF denotes the distance on the optical axis from the imageside surface of the second image-side lens up to the image, and
- L_L denotes the distance on the optical axis from the objectside surface of the first object-side lens up to the imageside surface of the second image-side lens.
- 10. The optical system according to claim 9, wherein the following conditional expressions (35) and (36) are satisfied:

$$1.0 < D_{ENP}/Y$$
 (35)

$$0 \le CRA_{obj}/CRA_{img} \le 0.5 \tag{36}$$

where

- D_{ENP} denotes a distance on the optical axis from a position of an entrance pupil of the optical system up to the object-side surface of the first object-side lens,
- Y denotes a maximum image height in an overall optical system.
- CRA_{obj} denotes a maximum angle from among of angles made by a principal ray that is incident on the first object-side lens, with the optical axis, and
- CRA_{img} denotes a maximum angle from among of angles made by a principal ray that is incident on an image plane, with the optical axis, and
- an angle measured in a direction of clockwise rotation is let to be a negative angle, and an angle measured in a direction of counterclockwise rotation is let to be a positive angle.

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